CALCULATING SAFE DISTANCE FROM MINE EXPLOSION AREA DURING CONSTRUCTION PROCESS OF TAM DAO I – TAM DAO II ROUTE

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ABSTRACT

Tam Dao I – Tam Dao II route is inside Tam Dao National Parks with the length of 9.16 km and width of 3,5 m. The route is constructed on land with ground elevation fluctuate from +7.4 to +11.5 m, geological structure consisting of rocks Tam Dao formed with erupted magma, which create a necessity to use drills and explosions. RocFall model and iGeoHazard software were applied to simulate the range and safe radius while using 3800 kg of dynamite, results showed: the distance needed to be safe from concussion and blast wave was 100 m from the center of the blast, the furthest rolling and scattered rocks could be seen was 200 m from the blast and following valley.

To minimize the effect of mine explosion, this article suggested: control mine explosions with differential explosive devices, shallow holes; mines are detonated at a specific time during the day, setting up fence systems at detonated positions with a distance less than that of simulated impacts.
Keyword: *Mine explosions, quake, rolling stones, Tam Dao, safe distance*

INTRODUCTION

Tam Dao National Park lying within Tam Dao mountain range and is a natural treasury where biodiversity is preserved with many different, unique and rare species of plants and animals [1]. Additionally, Tam Dao is a tourist attraction at Red river delta. However, infrastructures, especially routes that serve the development of Ecotourism in combination with with forest patrol, science researches and fire protections are not properly funded. Therefore, the route from Tam Dao I to Tam Dao II with 9.16 km long, 3.5 m wide and 4.5m roadbed thick was approved by Vinh Phuc Province people's committee to be built upon an already existing trail with an extension of 2,52 km [2]

The route was built on high terrain with altitude variation ranging from +7,5 to +115m, geological structure of mainly rock formed by erupted magma, which create a necessity to use drills and explosions. When mines explode, a portion of the energy breaks the rock and dirt, the rest is wasted under chemical loss [3]. Spare heat from explosive byproducts will heat up the surrounding environment, especially those that create kinetic energy with no benefit such as: shockwave, rolling stones and dust.

Usually the impact distance from the explosions is calculated using traditional formulas [4]. This kind of calculation has numerous benefits such as: easiness to do, no requirement for any complex programs, and fairly high accuracy. However, some disadvantages are that it can't simulate the impacts on the terrain. This article uses RokFall model (Rocsciences Inc – Canada) in combination with iGeoHazards program to calculate in order to combine both modern and classic elements in the research. The results identified the region, range, distance from the explosion in order to assist the assessment and create mitigations measures when building the route.

RESEARCH METHODS

The main method was to apply math models. This brings outstanding advantages: the result is shown quickly, accuracy is fairly high, it's flexible. However, the reliability of this method depends heavily on input numbers.

Currently in Vietnam, math models used in resource and environmental management are still limited. Each field has its own tools and models to fit its own requirements. For

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example, for storm and flood prediction there's French MARINE model, Mike11 of Denmark, SSARR, TANK,...

In the field of mine explosion, scattering rocks, land slide and noise vibration there's some prediction models including RokFall, KS-DYNA, UDEC [5][6]. Some benefits from using RocFall are as following: it's fairly accurate, it can calculate the distance and radius of scattering rocks when mine is exploded. Using iGeoMoment, programmed with Visual Studio to calculate the safe distance based on the amount of rocks needed to be demolished and form the basis to circle the affected area to limit negative actions.

RocFall is a risk analysis program to assist in assessing the stability of the slope capable rock landslide. This program is capable of calculating kinetic energy, velocity and bounce rate of a rock. Dynamic distribution, velocity, height, and statistical results are also calculated and displayed graphically along the slope.

RESEARCH RESULT AND DISSCUSSION

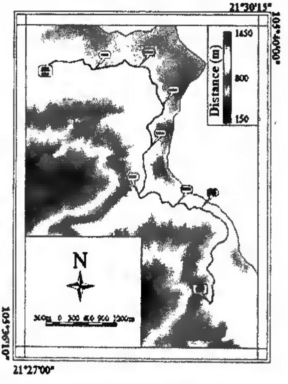

Fig. 1. *Area Topographic map*

Data used in calculation

Topographic conditions: Mainly hills and mountain with big slope from North East - South West. Altitude variates from +7.5 to +115 m. Background slope is less than 25% made up 46.9%, the rest variates from +51 to +115 m, and tilt is less than 35%. Young rockbed from the 4th era created a flat, homogeneous topography (Fig. 1).

Geological structure: In the area exists all kinds of rock belonging to Tam Dao Formation from Jurassic- early Cretaceous era with components mainly consisting of erupted rocks such as rhyolite porphyry, rhyolite, rhyolite dacit in underground level. Tam Dao Formation (J-K1 tdd1), in some places has grey porphyry quazt and tuff rhyolite (Fig. 2).

Detonation plan: Detonate explosives in shallow drilling holes (H < 5 m). This method can be applied with high precision, less impact to the foundation, suitable for rocks with hardness Protodiakonov f = 6-8.

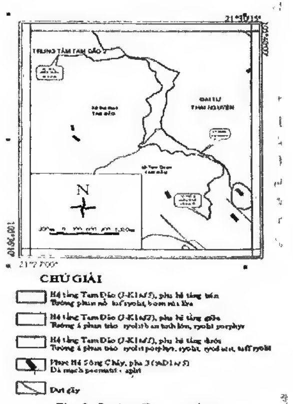

Fig. 2. *Project Topographic map*

The amount of explosives: Based on the amount of rocks needed to be demolished to create a roadbed to identify places to plant demolition charges. They are mostly set up continuously from Km 2+360 to Km 8+570, except from a few sections in the middle with unstable and weak geological structure. From these positions, we calculated the amount of explosives needed is 3800 kg (formula: Q=k.V (kg), with k: The amount of explosives needed for 1 unit of volume of rock (kg/m^3); V is the volume of rock demolished)

Calculations and result

Safe distance versus impact: When mines are exploded, the high pressure and temperature will create a powerful shockwave that can destroy the environment. The vibration caused by the explosions usually uses a part of their energy to destroy rocks, the rest is transfer to the environment under the guide of instantaneous waves such as: vibrant, compressed air, sound, air dust. The calculation of the safe distance required is performed according to Vietnam National Standard 02:2008/BCT: $R_c = K_c.\alpha.\sqrt[3]{Q}$.

Q is the minimum weight (kg), α is a coefficient relied on n, Kc is a factor relied on the quality of the quality of the project's ground. All coefficients are checked based on Vietnam National Standard 02:2008/BCT. The map shows the tilt of each detonating position, from there we identified the explosion impact index (Fig. 3).

Result of the calculation on the vibration for each position along the route allowed the encirclement of the affected area, at the same time identified the affected distance of approximately 30-35 m up to 85 m (Fig. 4). However, in the blast zone, there's little to no civilian structure therefore if there were any negative effects it would affect the worker's camp.

Safe distance versus shockwave

According to Nation Regulation on preserving, moving and using explosives, the safe distance is calculated as following:

$$R_b = k_b\sqrt{Q}\ \text{(m)}$$

Kb: coefficient dependent on the distribution of mines and the damages it causes (table inside National Standard 02:2008/BCT);

Q: The amount of explosives used.

If the protected structure is behind a forest block, Rb can be reduced but no more than ½. So the new formula is as following:

$$R_b = k_1k_2\sqrt{Q}\ \text{(m)}$$

K1: is a coefficient for the safety of a man in cover, K1 = 2.

K2: is a coefficient, it represents the safety available when there's an explosion in high mountains, K2 = 1,1.

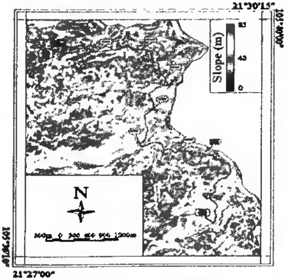

Fig. 3. *The tilt of the study area*

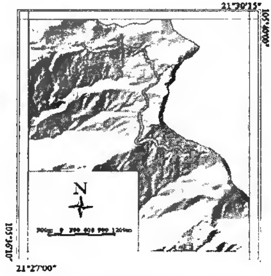

Fig. 4. *Circle the safe distance against impact*

Results allowed the creation of a safety from shockwave map for the whole route (Fig. 5).

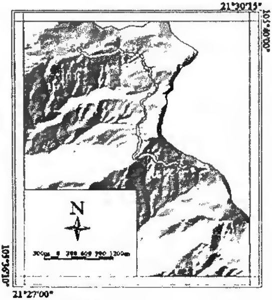

Fig. 5. *Circle the safety distance from blast wave*

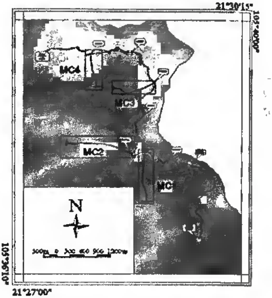

Fig. 6. *Positions of rolling stones simulating sections*

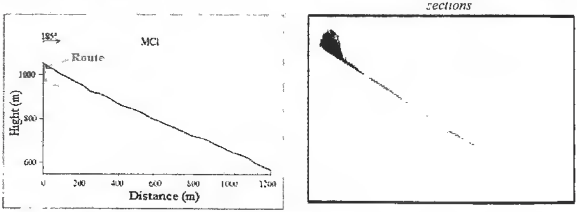

Fig. 7. *Cut section from position MC1 and simulate rolling stones at explosions*

Result showed the average safety distance of between 24-32 m, and up to 100 m in some places. The place where the route was constructed is on mountainous region, one side with plus talus of high cliff, the other side, minus talus of deep chasm. At the building position there has many layer of leaves therefore the effects of shockwave is reduced.

Calculating the possibility of rolling stone caused by explosions and gravity: During building period, explosive ingredients used was regulated to prevent the appearance of rolling stones. Simulations were performed on 4 sections representing 4 areas with the largest affected areas with no big trees to shield and reduce effects (Fig. 6).

Result from sections MC01 showed that rocks were blown away along the valley and concentrated into a piles of rocks, mostly within 10-120 m from the center of the blast. The highest speed achieved by the rocks was about 17 m/s at 10 – 15 m, after that it reduced gradually, the last rolling rocks was found stopping at 120 m (Fig. 7.).

Using similar method for MC2, MC3, MC4 showed similar patterns, rolling and scattered stones blown along the valley and forming piles of rocks, the difference was in the distance, 80-200 m, 40-70 m, 50-100 m, mostly at 160-180 m, 40-50 m and 60-70 m. The highest speed achievable was 23 m/s, 17 m/s and 16 m/s after that it gradually reduced, the last rolling stones stop at 215 m, 75 m and 100 m.

CONCLUSSION AND RECOMMENDATION

There is a clear distribution in the area topography, consisting of open core rocks; therefore explosives are required to clear a path. The total amount of explosives needed is 3.800 kg, this was calculated based on the amount of rocks needed to be removed, geological features and lithological composition.

The process required to blow up mines will heavily impact the surrounding areas, this is shown through vibrations, shockwave and danger of rolling stones/rocks. However, the route is built on or near the existing roadbed, according to investigation report on animal distribution in the area, there are no rare or exotic animal species, so the impacts is somewhat reduced [1].

The safe distance against vibration and shockwave is about 85 m and 100 m from the center of the blast respectively. With rolling stones, on tilt surfaces, the speed can reach up to 20 m/s, the furthest they can go is up to 200 m along the valley. This is also where plants grow, and animals in the area will be endangered by rolling rocks.

According to the calculations, this article suggested and recommended some basic first steps to minimize impacts from the explosions:

Control mine explosions with electronic differential explosions devices, in shallow holes. This is a new method (small size, similar holes, leave no traces on the floor and less cracks...), reducing rolling stones, shockwaves and vibration... and simultaneously reducing dust and noise.

Recommend to only use explosives at noon from 11:30 pm to 12:30 pm and in the afternoon from 16 hours 30 minutes to 17 hours 30 minutes, avoid early morning, sunset – the time when most animals go looking for foods, to prevent scaring them. Besides, using explosives only at a specific time of the day will increase the adaptability of animals within the National Park.

Set up fences around blast zones with distance more than simulated safe distance to isolate the construction area. When done with explosives, fences and barriers will be removed to not limit local animals interactions.

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TÓM TẮT

TÍNH TOÁN KHOẢNG CÁCH AN TOÀN NỔ MÌN TRONG QUÁ TRÌNH XÂY DỰNG TUYẾN ĐƯỜNG TAM ĐẢO I – TAM ĐẢO II

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Tuyến đường Tam Đảo I - Tam Đảo II nằm trong VQG Tam Đảo có chiều dài 9.16 km, mặt đường 3 5 m. Tuyến được thiết lập trên nền địa hình có cao độ từ +7.5 ÷ +115m, cấu trúc địa chất là các đá thuộc hệ tầng Tam Đảo với thành phần thạch học là magma phun trào, đặt ra yêu cầu phải khoan nổ mìn. Sử dụng mô hình RocFall, phần mềm iGeoHazards mô phỏng phạm vi và bán kính an toàn trong quá trình sử dụng 3800 kg thuốc nổ, kết quả chỉ ra rằng: Khoảng cách an toàn về chấn động và sóng đập không khí lớn nhất là 100m tính từ tâm chấn; khoảng cách xa nhất đối với đá lăn (văng) có thể đạt 200 m theo hướng xuôi về phía thung lũng.

Để hạn chế các tác động từ nổ mìn bài báo kiến nghị: điều khiển nổ mìn bằng phương tiện nổ vi sai, lỗ nông; tiến hành nổ mìn vào một thời điểm nhất định trong ngày; lắp đặt hệ thống rào tôn tại các vị trí nổ với khoảng cách > khoảng cách tác động mô phỏng.

Từ khóa: *nổ mìn, chấn động, đá lăn, Tam Đảo, khoảng cách an toàn*

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