भारत सरकार/ Govt. of India
एवं रोजगार मंत्रालय/ Ministry of Labour & Employment
सुरक्षा महानिदेशालय/ Directorate General of Mines Safety

सत्यमेव जयते

Mines Safety Association Karnataka

Mining Engineers Association Of India

National Conclave-2024

A Presentation on

PROBLEMS AND SOME PROBABLE SOLUTIONS IN QUARRY SECTOR WITH SPECIAL REFERENCE TO ROCK BLASTING

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Contents

- Introduction
- Quarrying
- Case Studies
- Best Practices
- Problems & Some Suggestions

History of Quarrying

- Mining is extraction of mineral from earth's crust. Though any open pit forms a quarry, in general quarry term is limited to extraction of stone (including sand) for building materials for any construction project.
- Quarries have been used for thousands of years.
- Ancient Egyptians built the Great Pyramids with massive limestone and granite blocks cut by hand from nearby quarries.
- At a site in Pipestone National Monument, in the U.S. state of Minnesota, they quarried for stones to make calumets, or ceremonial smoking pipes. Calumets, made of a type of metamorphic rock called catlinite or pipestone.
- Flintstone (used to make tools) was known and exploited by the inhabitants of the Indus Valley civilization by the 3rd millennium BCE.
- There are many evidences of usage of rock for different tools in the history long ago.
- Infact Quarrying is part of Mining, the history of Mining dates back to more than 4000 years.

Why Quarrying?

Aggregates: Aggregates, such as crushed stone, sand, and gravel, are the most common materials used in the construction of infrastructure projects. They are used as a base or sub-base for roads, as well as in concrete and asphalt mixes for pavement construction.

Dimension stones: Dimension stones used for cladding, flooring, and other decorative purposes in buildings and monuments.

Riprap: Riprap, which is large rocks or concrete blocks, is used to protect shorelines, embankments, and other erosion-prone areas from the effects of water and wind.

Ballast: Ballast, which is a layer of crushed stone or gravel placed under railroad tracks, is used to provide stability and drainage to the tracks.

Fill material: This is a type of soil or rock that is used to fill in areas where the ground has been excavated for construction or other purposes.

Need for Quarrying

- Quarrying is essential to supply large quantity of raw material for infra projects.
- Sand mining is banned /restricted in many states, so fine aggerates are also to be supplied by quarry sector in place of sand.
- **On the other hand, Quarrying/mining is being treated as a negative activity in general and facing many problems.**

Some of the problems faced by Quarry sector

- Lack of availability of good deposits
- Stringent regulations
- Multiple reregulating bodies
- Close to human habitats and sensitive areas
- Non cooperation of local people
- Linking land slides (slope stability) to quarrying activity in the recent past.
- *Negative image of rock blasting, where as blasting is essential in quarries.*

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- After obtaining the Lease from DMG, Quarry plan will be prepared and submitted to SEAC.
- SEAC is asking now a days two specific scientific studies
  - Scientific study to assess the stability of slopes
  - Scientific study to assess the effect of blasting on the surrounding structures

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During my last 22 years of service

- Completed 220 industry sponsored consultancy projects
- 100 projects related to rock blasting
- 100 projects related to slope stability
- 20 projects other areas

Among them

- 65 projects are related to only quarry sector in the states of Karnataka, Tamil Nadu, Kerala, Andhra Pradesh
- A few case studies are presented here

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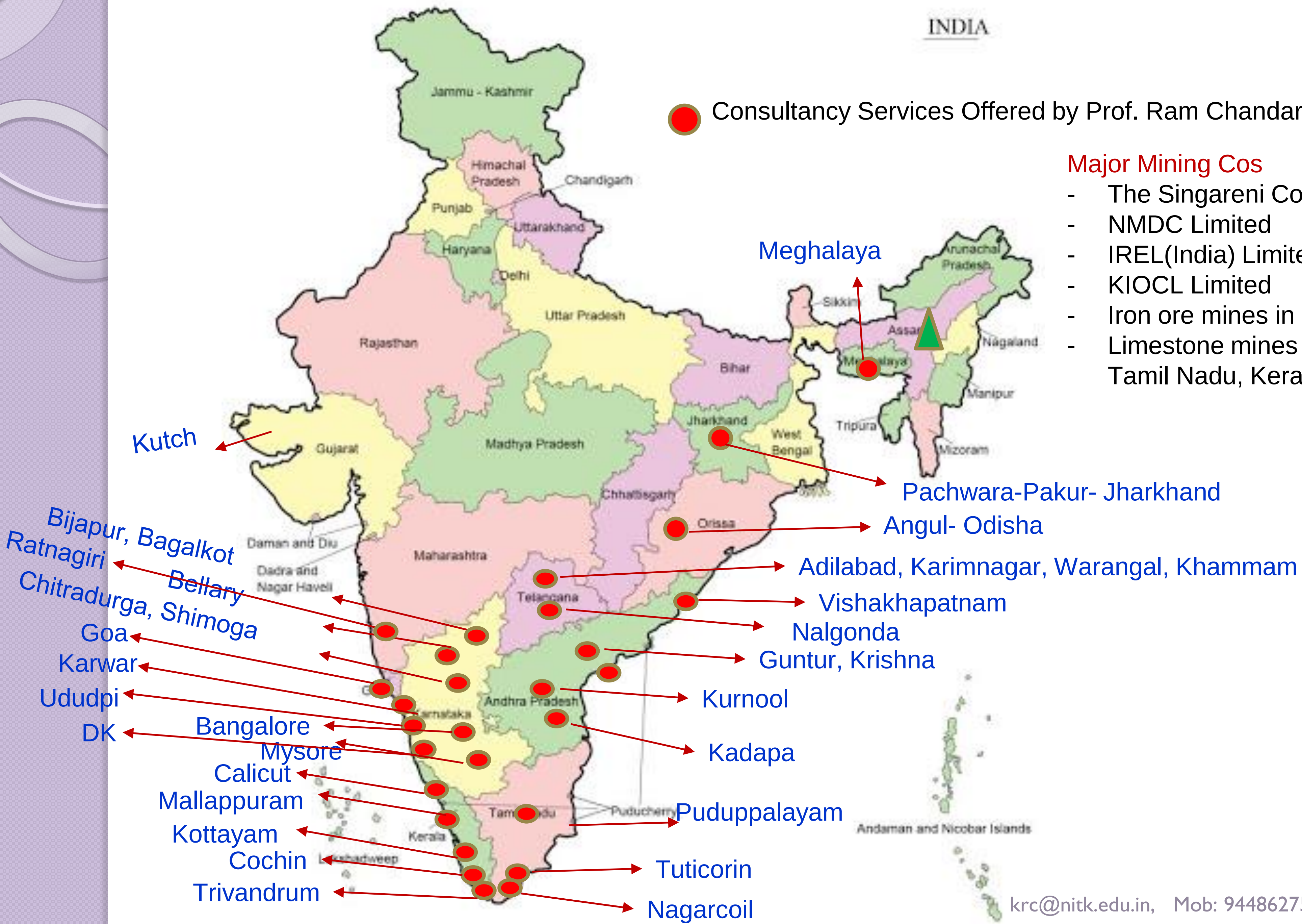

Major Mining Cos

- The Singareni Collieries Co. Ltd
- NMDC Limited
- IREL(India) Limited
- KIOCL Limited
- Iron ore mines in Goa and Karnataka
- Limestone mines & Quarries in Karnataka, Tamil Nadu, Kerala, Telangana, AP.

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Rock Blasting

Blasting is a process of breaking the rockmass using chemical energy in the form of explosives

Purpose of Blasting

- For digging mines
- In tunnels
- For construction works like hydel projects
- To clear hard rock for canals, pipelines, roads, buildings or any other civil projects
- To damage cities,
- Destroy ships and airplanes
- To kill enemy troops

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Explosives are substances that produces a rapid, violent reaction when exposed to heat, a strong blow or a special detonator. During the reaction, explosives give off large amounts of gases at high pressure.

Factors Influencing Blast Performance

Controllable factors

- Blast geometry parameters
- Explosive properties
- Initiation system & initiation pattern

Uncontrollable factors

- Physio-mechanical properties
- Geological discontinuities

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TABLE - PARAMETERS INFLUENCING GROUND VIBRATIONS
(Wiss and Linehan, 1978)

Parameter	Influence on PPV		
	Significant	Moderately Significant	Insignificant
A. Controllable Variables			
Charge Weight per Delay	✓		
Length of Delay	✓		
Burden and Spacing		✓	
Stemming Amount		✓	
Type of Stemming			✓
Charge Length and Diameter			✓
Angle of Borehole			✓
Direction of Initiation		✓	
Charge Weight per Blast			✓
Charge Depth			✓
Bare Vs. Covered Detonating Cord			✓
B. Uncontrollable Variables			
General Surface Terrain			✓
Type and Depth of Overburden		✓	✓

Case Study-1

- This is a case study of a quarry in Thiruvananthapuram District of Kerala.
- This is a new quarry and there were concerns as there is a water tank at a distance of around 30m from the lease boundary.

Quarry

Water tank

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Any scientific study requires

- A subject expert
- Should carry a pre-bast survey
- Blast design based on site conditions
- Execution of blasting along with monitoring with suitable instruments
- Post blast survey and analysis

Major Concerns

- Ground Vibrations
- Noise
- Fly rock
- Fragmentation (secondary breaking to be avoided)

Pre- Blast Survey

Trench

Blast Design Parameters

Sl. No.	Parameters	Suggested Value
1	Diameter of Blasthole (mm)	32
2	Burden (m)	0.91
3	Spacing (m)	1.21
4	Depth of Blasthole (m)	1.51
5	No. of Blastholes	Maximum of 30
6	Explosive Charge / Hole (gm)	375
7	Maximum Charge / Delay (gm)	375
8	Initiation System	shocktube detonators
9	No. of Rows	Maximum of 3

PPV Values

Distance (m)	Peak Particle Velocity (mm/s)	Noise (dB)
100	0.56	92.07
35	4.40	97.36
60	**<0.51 (beyond trench)**	-
55	3.25	86.71
75	**<0.51 (beyond trench)**	
65	2.38	99.35
80	1.679	118.5
50	3.71	98.51
75	2.301	113.6

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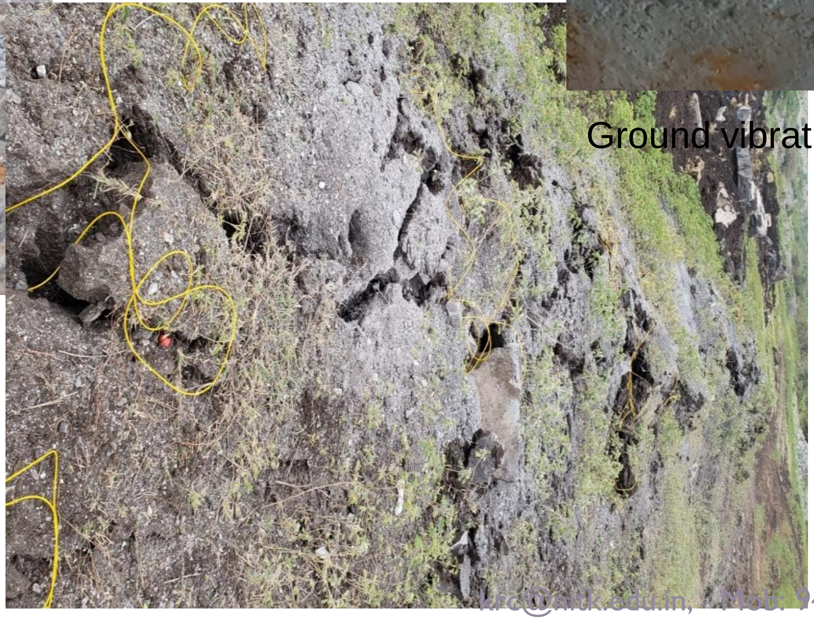
Case Study- 2

- This case study is taken in Guntur District of Andhra Pradesh.
- There are some houses and a temple beyond 200m.

Quarry

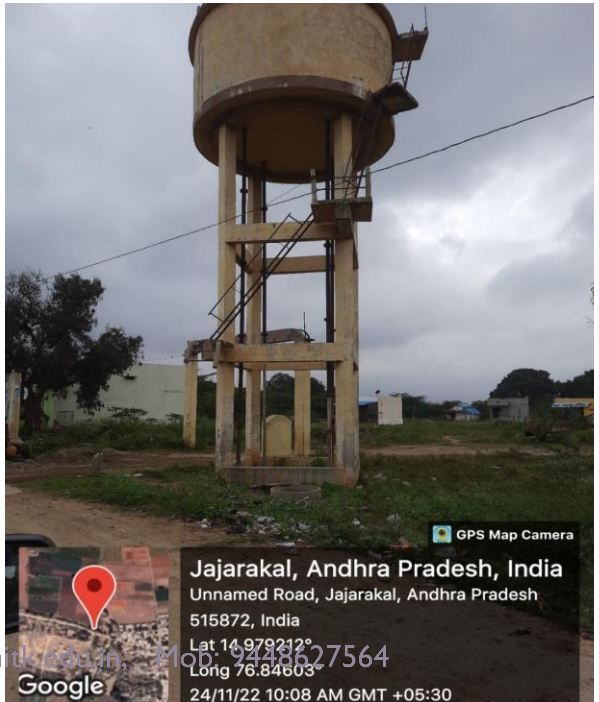


Pre-split plane

Ground vibration monitoring near temple

Case Study- 3

- This case study is taken in Anantapur District of Andhra Pradesh.
- There are some houses, school, water tank, temple beyond 300m.



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Controlled Blasting is Site Specific

- Case Study-1: Trench/ Open channel
- Case Study-2: Pre- Split plane
- Case Study-3: ……

Optimization of Blast Performance Vis A Vis Controlled Blasting

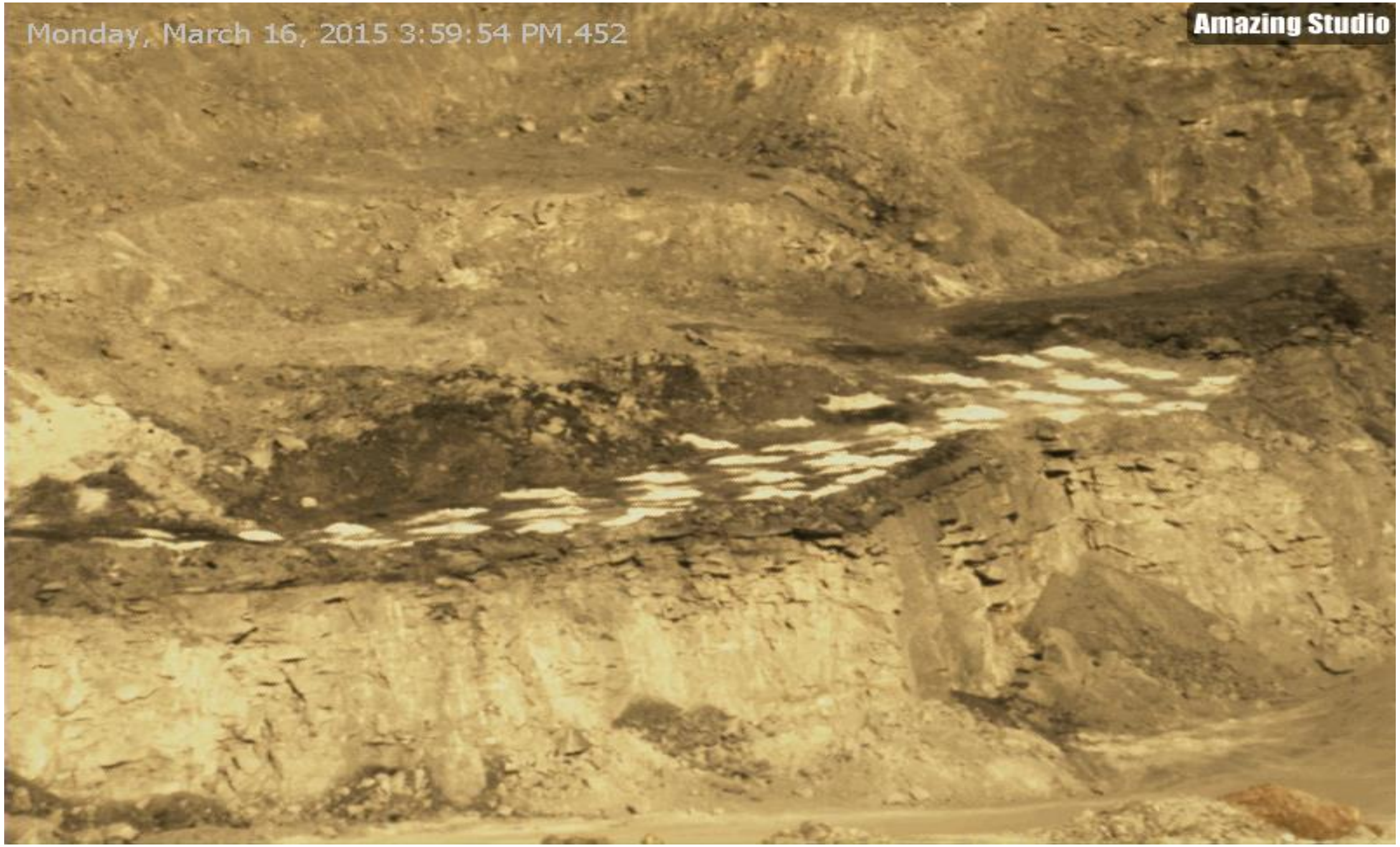
- Rock Properties
- Blast Geometry
- Explosives & Initiating Devices
- Pre-split plane, trench, series of blastholes

All the above are being experimented in different quarries. Then what next?

Possibility / feasibility of Electronic Detonator

D-cord

Nonel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Amazing Studio

Use of High Speed Camera

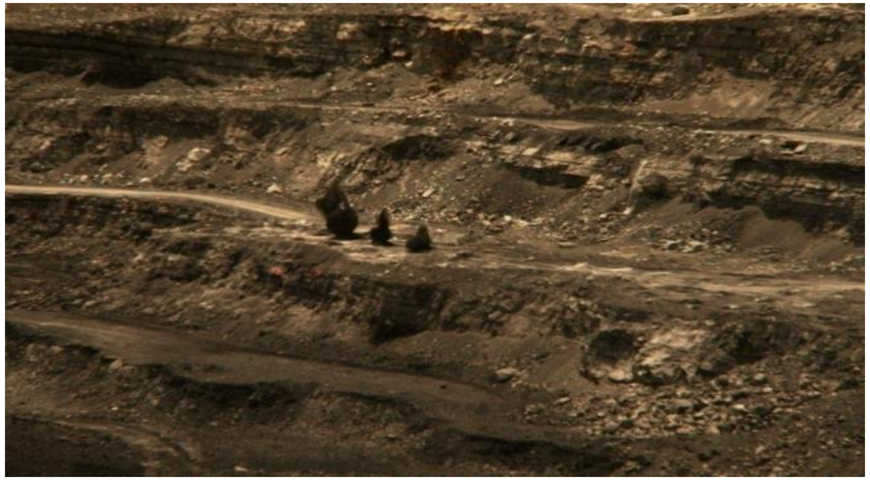
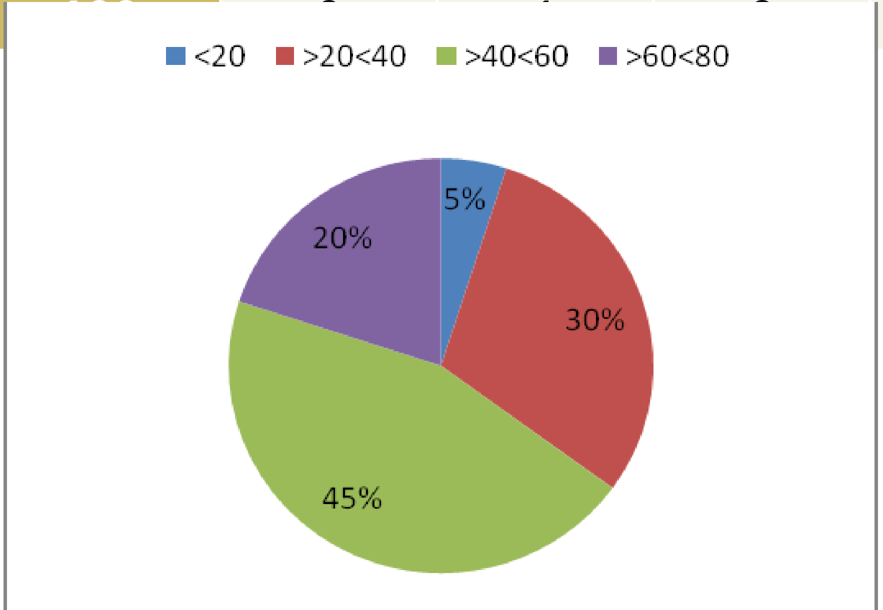
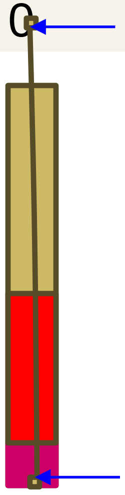


TABLE - RANGE OF SURFACE AND IN-HOLE INITIATION ERRORS

Range of % Error	Blast No.1		Blast No.2		Blast No.3	
	Surface Error	In-hole Initiation Error	Surface Error	In-hole Initiation Error	Surface Error	In-hole Initiation Error
<20	1	0	0	0	9	1
>20 - <40	6	0	5	0	5	3
>40 - <60	9	5	3	3	7	4
>60 - <80	4	6	3	8	1	3
>80 - 100	[illegible]	[illegible]	[illegible]	2	0	0





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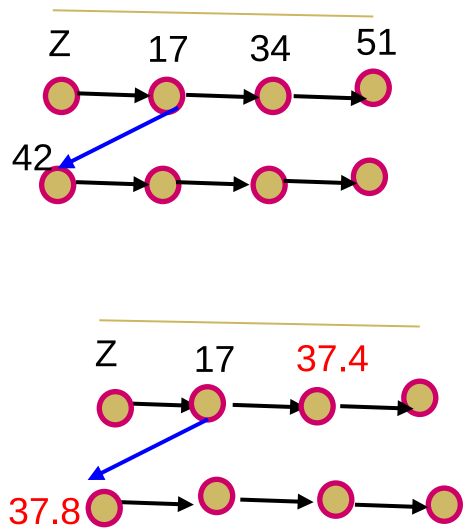
Effect of error in delay timing

1. Delay timing as per the design



2. Delay timing with 10% error

PPV = K(D/SQRT(W)$^{-b}$

In Case-1: MCD= Charge per hole
In Case-2: MCD= 2x Charge per hole

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Based on the above findings, a new R&D project was proposed to Ministry of Mines- Govt of India

"Definition of Delay Sequencing in Blast Designs Using Advanced Analytical Techniques for Optimization of Blast Fragmentation and Improving Mine Economics in Non-Coal Mines [Project Code: SNTMOM/67/2020]"

Under this project- Specific guidelines will be developed to use the electronic delay detonators timing with millisecond accuracy for the given geo-mining conditions

Table 1. Results of delay accuracy measurements (for a detonator programmed to 3750 ms)

Detonator no.	Time [ms]				
	Electroacoustic sensor	Open-circuit probe	High-speed camera	Data recorder	
				1-2 °C	30 °C
1	3746.30	3749.907	3749.9	error	3749.521
2	3754.38	3749.796	3749.8	error	3749.655
3	3747.25	3750.076	3750.1	3750.452	3750.155
4	3750.30	3750.040	3750.1	3750.533	3750.252
5	3747.32	3749.862	3749.9	3749.711	3750.060
6	3748.58	3749.890	3749.9	error	3749.753
7	3750.12	3749.897	3749.9	3750.325	3749.829
8	3748.77	3749.958	3749.9	error	3750.487
9	3749.61	3749.858	3749.8	error	3750.355
10	3750.18	3749.911	3750.0	error	3749.570
11	3752.47	3750.063	3750.0	error	–
12	3747.25	3750.103	3750.2	error	–
13	3751.71	3750.092	3750.0	3749.625	–
14	3752.13	3750.136	3750.2	error	–
15	3750.04	3750.103	3750.0	error	–
16	3747.41	3750.100	3750.0	error	–
17	3746.59	3749.950	3749.9	error	–
18	3751.30	3749.933	3750.0	error	–
19	3747.13	3750.036	3750.1	3750.373	–
20	3748.19	3749.947	3750.0	error	–
Average	3749.35	3749.983	3750.0	3750.170	3749.964
Deviation	2.24	0.102	0.1	0.396	0.344
Minimum time	3746.30	3749.796	3749.8	3749.625	3749.521
Maximum time	3754.38	3750.136	3750.2	3750.533	3750.487
Min–max	8.08	0.340	0.4	0.908	0.966

Pytlik & Mertuszka (2021)

High Energy Materials, 2021, 13, 143 − 156; DOI 10.22211/matwys/0211 ISSN 2083-0165

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Specific observations?

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Best Practices……

- Always ensure a proper free face for the blast
- Propagation of ground vibration should be away from the structure/ not towards the structure
- Clear off the small pieces of rock before starting drilling itself, so that fly rock can be avoided.
- Use muffling arrangement wherever human habitats are nearby.
- Follow all the safety aspects while handling of explosives and carrying out blasting operations

Maintain all the details of the blasts as a document

Sl. No.	Parameters	Blast No. 1	Blast No. 2
1	Date of Blast		
2	Time of Blast (Hours)		
3	Location of Blast		
4	Diameter of Blasthole (mm)		
5	Burden (m)		
6	Spacing (m)		
7	Depth of Blasthole (m)		
8	No. of Blastholes		
9	Explosive Charge / Hole (kg)		
10	Maximum Charge / Delay (kg)		
11	Total Charge / Blast (kg)		
12	Initiation System		
13	Initiation Pattern		
14	Location of Instrument 1		
15	Distance 1 (m)		
16	PPV 1 (mm / s)		
17	Noise 1 (dB)		
18	Fly rock		
19	Fragmentation		
20	Other remarks		
21			

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Specific Observation?

- Man power is not properly trained
- No usage of safety devices , including safety shoes
- Improper handling of explosives & initiating devices
- Charging all the holes at a time, and blasting them group wise
- No blaster’s shelter
- No proper warning system before blasting
- Improper initiating methods

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Some Suggestions

- Quarrying sector needs skilled man power
- Man power requires training in handling of explosives to conduct blasting efficiently without compromising on safety
- Training centres (Need not be MVTCs)may be established in specific places where more no of quarries are in operation.
- Need based training and periodic training to be provided.
- ‘Every quarry should have a manager’ may be changed to ‘One manager for maximum of ‘N’ number of quarries within a radius of ‘x’ km.
- Some of the regulations may be translated into regional leagues- Quarry owners Associations should take such responsibility and can involve some retired experts.
- Instead of enforcing the man power to follow regulations, educate them to realise the importance of following the rules and regulations (inters of safety)
- Quarry owners, regulating bodies, trainers/academicians, some retired technocrats, etc., should come together to improve the performance of man power in quarry sector.
- **I AM ALWAYS THERE WITH YOU FOR ANY KIND OF TECHNICAL HELP**

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Finally,

Two thumb rules

Rule-1: 3, 4,5

Rule-2: 375

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THANK YOU ALL

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