CHAPTER 05

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter provides conclusions of the research study. The chapter further presents contribution to the industry and further research.

5.2 Conclusions

Aggregates/ metals obtained by quarrying are one of the most commonly available mineral resources in anywhere in the country and is a basic raw material used by the construction industry (Herath, 2010). Due to the rapid increase of construction industry, the demand for rock is also increasing which in turn increase the number of metal quarries in the country. It is very difficult to find a systematically well-developed quarry although there is a high demand for aggregate products in Sri Lanka. Therefore, there is a need to enhance process performance in industrial quarry projects. Thus there is a need to implement concept such as lean philosophy in order to eliminate or minimize non-value adding activities and to optimize quarry operation.

Lean is a performance-based process and focus on the elimination of waste or non-value added steps within the entire industry or organization (McGivern & Stiber, 2014). Lean management also helps to increase the quality of products, reduce the operation time and decrease the production cost (Rylander,2013).

Lean principles have been applied in almost all type of manufacturing industries over the past 30 years since its origin from the Toyota production system and dramatically penetrate to the other industries like construction and mining (Andi et al., 2009). But in Sri Lanka, lean concept is not widely used yet except in few garment factories (Danasooriya, 2011). Therefore, this concept is also not familiar to the Sri Lankan mining industry and there is a lack of research findings on the applicability of lean

principle to minimize waste in Sri Lankan mining Industry. Therefore, it is time to investigate the benefits of implementing lean principle to the quarry industry. This research intends to perform the above mentioned investigation along with the in-depth analysis of quarry operation and it will help to add the term of lean concept to the Sri Lankan mining industry.

The aim of this research was to identify lean strategies to minimize waste in Sri Lankan quarry industry. In order to achieve this aim four objectives were formulated. First objective was achieved successfully through the comprehensive literature review and other three objectives were achieved through the empirical study which was conducted by chapter 04.

First objective was to review the lean concept and its application, mining industry and processes in quarry industry, the application of lean concept in mining industry and main industrial wastes/ non-value adding activities. This objective was successfully achieved through a comprehensive literature survey carried out by referring to books, journals articles, published research papers, unpublished dissertations and internet sources. End of the literature review the conceptual model for the study was developed as a main outcome of the literature survey (refer Figure 2.20).

The empirical study was carried out to achieve other three objectives. The second objective was to investigate the factors affecting wastes under main wastes in different processes in quarry industry. This was achieved through multiple case study research. Three industrial quarry projects which are under IML-A category (large scale) were selected under the multiple case study design to suit time constraints and convenience. Data collection for the case study was based on semi structured manner according to open ended questions to enhance the richness of the information collected (refer Annex A). The interviews were conducted with five participants for each case and altogether, 15 interviews were conducted. Cross case analysis was carried out separately under main eight wastes identified in the literature survey. Factors affecting wastes identified under each main waste category in the case study were categorised as avoidable and unavoidable (refer Annex C). Identified factors

were further categorized as highly critical, critical and not critical by considering respondents' responses (refer Annex C and Table 4.3). Finally, cognitive map was developed for all identified factors affecting wastes in Sri Lankan aggregate mining industry under main eight wastes, i.e.: (1)Over Production (2) Waiting / Delay (3) Unnecessary Transportation (4) Unnecessary Processing (5) Excess Inventories (6) Unnecessary Movement/ Motion (7) Defects (8) Underutilized People (refer Figure 4.9).

Breakdown and maintenance of machines, plants and vehicles was identified as a high critical avoidable factor affecting wastes for both over production and waiting/ delay. Double handling/ intermediate storage, Old plant, machine & vehicle, Excess finished products, Workers travelling unnecessarily looking for parts, tools, helps, Damage of Screen, Unsatisfied monthly salary and/ or Lack of salary increments/ bones/ incentives were some identified avoidable factors affecting wastes under Unnecessary Transportation, Unnecessary Processing, Excess Inventories, Unnecessary Movement/ Motion. Defects, Underutilized People respectively (refer Table 4.3 & Figure 4.9).

Unavoidable factors were only identified under four main wastes i.e. over production, waiting/ delay, unnecessary processing and defects. Bad weather condition, safety issue in the blasting time, bore holes fill with water, raining were some factors respectively.

Lean strategies were discussed only for the highly critical and critical factors affecting wastes, which are under avoidable category. The proposed strategies by respondents were linked to relevant lean strategy by considering literature review and desk study. Accordingly 14 lean strategies i.e. TPM, Work Standardization, JIT, Bottleneck analysis, PDCA, Takt time, Kanban, 5S, Kaizen, TQM, Visual Control, Poka-Yoke, Jidoka, Daily huddle meeting were identified to minimize wastes in Sri Lankan quarry industry by this study (refer Table 4.12).

Finally, initially developed conceptual model (refer Figure 2.20) was modified by adding avoidable high critical and critical factors affecting wastes and relevant lean

strategies. This framework to minimize waste (non-value adding activities) in Sri Lankan quarry industry gives the final outcome of the research (refer Figure 4.10).

All top and middle management of the aggregate mining industry can use this framework. If any aggregate mining industry has any factors that would ultimately arise main waste, they can implement relevant lean strategies illustrated in the framework to minimize wastes and optimize the performance of quarry industry.

5.3 Recommendations to the Mining Industry

The lean concept is not familiar to the Sri Lankan mining industry and there is a lack of research findings on the applicability of lean principle to minimize waste in Sri Lankan mining Industry. This research intends to perform the above mentioned investigation along with the in-depth analysis of quarry operation and it helps to add the term of lean concept to the Sri Lankan mining industry. This was the main contribution to the industry.

Purpose of this study is to identify lean strategise to minimize waste in Sri Lankan quarry industry. Therefore, the research mainly focuses to find out the factors affecting wastes under main eight industrial wastes, lean strategies to minimize wastes and introduce a new framework to minimize wastes in quarry industry. These findings are other contributors to the industry and based on above findings following recommendations can be made.

- To use the proposed framework to identify the relevant main industrial wastes (NVAA) and applicable lean strategies, after identify the affecting factors.
- To implement the proposed framework as necessarily in quarry industry to optimize the performance by minimizing wastes.
- To use for other mining industries with some minor modifications.

5.4 Recommendations for Further Research

Following ideas can be highlighted for further research by considering this research.

1. Apply the proposed framework for wider cases to evaluate the validity and generalisability of the framework.
2. Extend the study to identify lean strategies to minimize wastes in all 6 stages, Prospecting, Exploration, Development, Exploitation, Processing and Marketing in Sri Lankan aggregate mining industry.
3. Extend the study to identify lean strategies to minimize wastes in underground mining processes in Sri Lankan mining industry.

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ANNEX A: CASE STUDY INTERVIEW GUIDELINE

Department of Building Economics,

University of Moratuwa,

Katubedda.

……

……

……

Dear Sir/ Madam,

Re: Dissertation – MSc in Project Management, University of Moratuwa.

I am Lakshitha Dinesh Jayalath, following an MSc in Project Management degree programme of the Department of Building Economics at University of Moratuwa. I am conducting a research under the supervision of Dr. YasangikaSandanayaka on "Identifying lean strategies to minimize wastes in Sri Lankan quarry industry". This concept is not familiar to the Sri Lankan mining industry and there is a lack of research findings on applicability of lean principle to minimize wastes in Sri Lankan mining industry.

There is a high demand for aggregate products in Sri Lanka, but it is very difficult to find a systematically well-developed quarry site. Therefore it is time to investigate the benefits of implementing lean principles to the quarry industry. This research is performed along with the in-depth analysis of quarry operations by doing selected case studies. Therefore, I seek information from your project site. I would be grateful if you could kindly allow me to obtain information from your project under the attached guidelines. The actual names of the projects and the interviewees will not be revealed in this report or any other document relating to this study. The information provided will be treated with strict confidence.

Thank You.

Jayalath S.D.L.D.,
MSc Student
Department of Building Economics,
University of Moratuwa,
E-mail: sdldjayalath@gmail.com
Mob: 077-2206948

INTERVIEW GUIDELINE

PART 1

Background Information

Name of the Organization/Project (Optional): ……

Name of the Respondent (Optional): ……

Designation of the Respondent: ……

Years of Experience: ……..

PART 2

General Information of Industry

2.1. Please give general information of the site based on the guide given below.

a) Name of the developer (Optional)
b) Date of Commencement
c) Location of the site
d) Objective of the project
e) Production categories
f) Total number of employees

2.2. Please give brief introduction of the Exploitation / Quarrying stage based on the guide given below.

a) Licence category of the quarry
b) Total area of the quarry
c) Permitted area for the quarrying activities
d) Total estimated rock volume of this permitted area
e) Applied mining method
f) Permitted blasting parameters
g) Number of employees

h) Present demand and supply of each category.

Production category	Present Demand	Currently achieving Qty (Present Supply)

i) Briefly introduce

- Drilling process
- Blasting process
- Mucking, scaling and breaking processes
- Loading process
- Transportation process

2.3. Please give brief introduction of the Processing / Crushing stage

a) Machineries using for crushing process with their capacities

b) Number of employees

c) Demand and supply of each category.

Production category	Present Demand	Currently achieving Qty (Present Supply)

PART 3

Identification of wastes in exploitationand processing stages in quarry projects

3.1. Over production wastes

a) Is there any excess quarry production? Yes ☐ No ☐

b) If "Yes"

i) How much and which categories?

ii) Why this excess production is keeping?

iii) What are the actions (strategies) taken to reduce?

c) If "No"

i) Is it same as demand or less?

ii) Have you face any problem due to none having excess production?

d) Is there any excess crusher production? Yes ☐ No ☐

e) If "yes"

i) How much and which categories?

ii) Why this excess production is keeping?

iii) What are the actions (strategies) taken to reduce?

f) If "No"

i) Is it same as demand or less?

ii) Have you face any problem due to none having excess production?

3.2. Waiting/ Delay

a) Please answer to the following

	Are there any delays due to	**Yes/ No**	**If "Yes", Details**	**Proposed actions/ suggestions/strategies to reduce delays**	**If No, what are the strategies used to reduce delays?**
1	Machine and / or plant breakdowns and / or maintenance?				
2	Waiting for materials?				
3	Waiting for equipment/tools?				
4	Waiting for information / instructions?				
5	Present site layout?				
6	Any other reasons?				

b) Are there any delays between subsequent processing steps / is there any waiting time for the next processing step?

	Subsequent Processing Steps	**Yes/ No**	**If "Yes", Details**	**Actions/ suggestions/strategies to reduce delays**	**If No, what are the strategies used to reduce delays?**
1	Drilling – Charging				
2	Charging-Blasting				
3	Blasting-Mucking, Scaling & Breaking				
4	Breaking – Loading				
5	Loading – Transporting				
6	Transporting – Processing				

c) What is the current production cycle time?

d) What are the actions (strategies) taken to reduce cycle time?

3.3. Unnecessary Transportation

a) Briefly explain about internal and external transportation use in the site.

Use Methods	**Approximate distance**	**Is there any possibility of reducing distance?**	**If there is a possibility, how to reduce?**
Internal transportation			
External transportation			

b) Are there any delays in above transportation methods?

c) If there is a delay what are the reasons?

d) Propose actions/ strategies/ suggestions to reduce delays?

e) Is there any intermediate storages/ double handling occasions?

f) If yes, what are the reasons for intermediate storages/ double handling?

g) Is there any possibility of reducing intermediate storages/ double handling?

h) If there is a possibility, How to reduce?

3.4. Unnecessary processing

a) What is the average timerequired and currently taking time for each stage?

Stage	**Qty**	**Average time required**	**Actual time**
Drilling			
Charging & Blasting			
Mucking, Scaling &Braking			
Loading			
Transporting			
Processing/ Crushing			

b) If above times do not tally with each other, what is the reason for that?

c) What kind of strategies can be taken to tally these times?

d) If above times are tally with each other, what kind of strategies are already used?

e) Are there any inappropriate production/ processing steps in this site?

f) If yes, do you have taken any actions (strategies) to eliminate those?

3.5. Excess Inventories

a) What is the minimum required and currently use of inventories to achieve present demand?

	Item	**Minimum requirement**	**Current availability**
Machineries			
1.	Rock drilling machine/ Track drilling machine		
2.	Air Compressor		
3.	Excavator		
4.	Breaker		
5.	Loader		

6.	Exploder		
7.	Dump trucks		
8.	Double cab/ Jeep		
9.	Vibrating feeder		
10.	Jaw crusher		
11.	Cone crusher/ Impact crusher		
12.	Vibrating screen		
13.	Generator		
14.	Water bowser		
15.	Any other		
Material			
1.	Drill bits		
2.	Drill rods		
3.	Ammonium Nitrate		
4.	Dynamite/ Water gel		
5.	Electric/ Plane detonators		
6.	Fuel		
7.	Grease		
8.	Hydraulic Oil		
9.	Engine oil		
10.	Any other		

b) If above numbers do not tally with each other, what is the reason for that?

c) Do you have any actions/ strategies to keep minimum requirement?

3.6. Unnecessary Movement/Motion

	Exploitation / Quarrying stage		**Processing / Crushing stage**	
	Machinery Movements	**Human Motions**	**Machinery Movements**	**Human Motions**
Types				
Are there any unnecessary…….? (Eg: Turning, Lifting, Reaching, Traveling/ looking for parts, tools, helps, etc.)	Yes / No	Yes / No	Yes / No	Yes / No

If yes, What are those?				
What are the reasons for these movements/ motions?				
Is there any possibility to reduce these movements/ motions?	Yes / No	Yes / No	Yes / No	Yes / No
If yes, what are the strategies taken to reduce?				

3.7. Defects

a) Which production categories are demanded by the customers?
b) What are the quality requirements expected by the customers in each category? Sieve analysis, Flakiness Index, Loss Angelies Abrasion Value (LAAV), Aggregate Impact Value (AIV)
c) What actions are currently taking to maintainrelevant qualities?
d) How to eliminate the adding of foreign materials / impurities to the production?
e) Is there any possibility to arise quality issues in production?
f) If yes, what are those?and what actions (strategies) can be taken to eliminate these issues?
g) Is there any possibility to reject the productions due to poor quality?
h) Has your organization faced to that type of occasions?
i) If your organization would have to face these types of occasions, how to handle rejected productions?
j) Is there any scrap production in your site?
k) If yes, do you have any suggestions (strategies) to minimize this scrap production?
l) Do you think that any repairs of machines and/ or plant is a solution for maintain production quality?

3.8. Underutilized people

a) What are the minimum required and currently using employees for each stage to achieve present demand?

Stage	**Minimum requirement**	**Actual availability**
Drilling		
Charging & Blasting		
Mucking, Scaling & Braking		
Loading		
Transporting		
Processing/ Crushing		

b) If above numbers do not tally with each other, what is the reason for that?
c) Do you have any actions/ strategies to keep minimum requirement?
d) Has each employee got target to achieve? Please explain those?
e) Do you have any employee controlling process to reach their targets?
f) Do you have any monitoring programme to compare performance against targets?
g) How are their performances?
h) If they cannot achieve their targets, what are the reasons for that? What type of corrective actions can be taken?
i) If they can achieve their targets, which methods can be implemented to increase the progress of work?
j) Does this business culture de-motivate the employees?
k) If yes, please explain the situation?
l) As you believe, is this project use their employee creativity, physical skills and abilities in success to reach to the project goal?
m) Please explain those situations?

ANNEX B: SAMPLE CASE STUDY INTERVIEW TRANSCRIPT

PART 1

Background Information

Name of the Organization/Project (Optional): Quarry and crushing plant project (Case A)

Name of the Respondent (Optional): Respondent A1

Designation of the Respondent: Site Manager

Years of Experience: 08 years

PART 2

General Information of Industry

2.1. Please give general information of the site based on the guide given below.

g) Name of the developer (Optional): *Case A*

h) Date of Commencement: *2003*

i) Location of the site: *Kaluthara District*

j) Objective of the project:

To provide aggregates and boulders for building and road construction projects in surrounding areas.

k) Production categories:

ABC (0-40mm), Asphalt aggregates (0-4mm: Dust, 4-8mm:Chip, 8-16mm:1/2inch, 16-20mm:3/4inch), Concrete aggregate (12-20mm), C1 (0-500mm), Boulders (1/2-2 ton).

l) Total number of employees: *45 nos.*

2.2. Please give brief introduction of the Exploitation / Quarrying stage based on the guide given below.

j) Licence category of the quarry: *IML - A*

k) Total area of the quarry: *4.5 Hectares*

l) Permitted area for the quarrying activities: *1 Hectares*

m) Total estimated rock volume of this permitted area:

Remaining rock volume is about 1,500,000 ton.

n) Applied mining method:

Multi bore–hole blasting method using compressed air driven hand drills and electric detonators.

o) Permitted blasting parameters:

This is different with the production category of the quarry. If we do a blast for feed to the crusher plant to take aggregate normally we keep 1.5m x 1.3m spacing and burden. Explosive is charged by keeping a powder factor 2.5-3 kg/m3. Hole depth is 4m and diameter is 40mm. 20- 30 charged bore holes fire at same time. Also in these days we have to supply 1/2 -2 ton size boulders to railway project. For that we keep 1.5m x 1.5m spacing and burden. Powder factor keep in below 2kg/m3.

p) Number of employees: *28 nos.*

q) Present demand and supply of each category.

Production category	**Present Demand**	**Currently achieving Qty (Present Supply)**
Quarry run for crusher	*1000 ton/ day (8 hours)*	*1200 ton/day (8 hours)*
Boulders (1/2-2 ton)	*Total qty 25,000 ton*	*Remain only 3,000 ton*

r) Briefly introduce

- Drilling process

  Drilling is done by a subcontractor. They use 3 air compressors, 3 jack hammers and 6 drillers. Normal drilling capacity is 250ft/hr by one jack hammer.

- Blasting process

  Use ANFO and water gel explosives. Daily around 60 holes are blasted but not fire together. Charge as 2-3 blast and fire as it is.

- Mucking, scaling and breaking processes

  For mucking and scaling we use excavators. Brakering is done by hydraulic breakers attached to excavators.

- Loading process

Blasted rock load to the dump trucks by using excavators and crusher productions is load to the dump truck by using both excavator and wheel loader.

- Transportation process

  Loaded dump trucks are travel from quarry to crusher plant to feed blasted rocks. It has a distance of about 100m. Aggregate production is sent from crusher to relevant projects. The traveling distance varies with the project. Some time it takes around 50kms.

2.3. Please give brief introduction of the Processing / Crushing stage

d) Machineries using for crushing process with their capacities

Jaw Crusher (1 nos.) – 150 ton/hr

Cone crusher (2 nos.) – 150ton/hr

Primary Screen (1nos.) – size 8feet x 12feet

Secondary Screen (1nos.)- Size 12feet x 16feet

e) Number of employees: *17 nos.*

f) Demand and supply of each category:

Demand is depend with project to project and difficult to predict it. Anyway demanded quantity by the projects we need to supply. So we try to achieve more than demanded in every month.

PART 3

Identification of wastes in exploitation and processing stages in quarry projects

3.1. Over production wastes

g) Is there any excess quarry production? *Yes*

h) If "Yes"

i) How much and which categories?

Rock material is a critical one of the supply chain of the construction project and there is a machine fleet demanding continues material supply for the project. Therefore we shouldhave enough quantity of aggregate materials at any time as the project expect. Daily demand of any construction project can vary and is not same in every day. Therefore excess quarry production should

be maintained. But it is difficult to give an exact figure for quantity that should be maintained because it depends on time. But we target to achieve in any category around double production of the average demand is needed.

ii) Why this excess production is keeping?

Quarry operations are immensely affected by weather conditions. For example blasting operations cannot be carried out during rainy time. Therefore excess production helps to maintain the demand without a break. Also aggregate demand is not a constant quantity. It greatly depends on the type of construction being carried out. Hence excess inventory is essential to match the demand. On the other hand even though the machines are maintained at the required level, breakdowns are unavoidable. In some days all excavators in site have been broken down. Therefore to minimize the effect to supply due to machine breakdown excess production is necessary.

iii) What are the actions (strategies) taken to reduce?

No strategies are required because excess amount is necessary.

i) Is there any excess crusher production? *Yes*

j) If "Yes"

i) How much and which categories?

Same in quarry here also try to achieve at least double production of the demand in any category.

ii) Why this excess production is keeping?

As explain before to face bad weather, uneven fluctuation of the daily demand and specially breakdown of machines, plants and vehicles. As an example, our Jaw unit of the crusher plant had been broken down for 3 months, but still has not repaired, because parts are not available in the country. Therefore we used our excess crusher production for one week until the mobile crusher was delivered to the site.

iii) What are the actions (strategies) taken to reduce?

No need to take any strategies to reduce.

3.2. Waiting/ Delay

e) Please answer to the following

	Are there any delays due to	**Yes/ No**	**If "Yes", Details**	**Proposed actions/ suggestions/strategies to reduce delays**	**If No, what are the strategies used to reduce delays?**
1	Machine and / or plant breakdowns and / or maintenance?	*Yes*	*Jaw breakdown of the crusher caused crushing delay.*	*Use company owned mobile jaw for crusher.* *Analyze critical steps of the process, and allocate the crushers suitably.* *Proper machine maintenance after operating hours.*	
2	Waiting for materials?	*No*			*Use material records it could purchased when reach a critical value*
3	Waiting for equipment/tools?	*No*			*Because company service team maintains equipments properly*
4	Waiting for information / instructions?	*No*			*Employee at any level can contact the required person directly hence can get*

					the correct information
5	Present site layout?	*No*			Identified site layout issues already rectified.
6	Bad weather	*Yes*	All activities in the process have to be stopped	Cannot take any action	

f) Are there any delays between subsequent processing steps / is there any waiting time for the next processing step?

	Subsequent Processing Steps	**Yes/ No**	**If "Yes", Details**	**Actions/ suggestions/strategies to reduce delays**	**If No, what are the strategies used to reduce delays?**
1	Drilling – Charging	*No*			
2	Charging-Blasting	*Yes*	After charging, before initiate the blasting all persons and machines should be evacuated to the safe locations and it takes some time (around 20 min)	Cannot take any actions to reduce	
3	Blasting-Mucking, Scaling & Breaking	*No*			
4	Breaking – Loading	*No*			
5	Loading – Transporting	*No*			

6	Transporting – Processing	*No*			

g) What is the current production cycle time?

After drilling is completed blasting is done in the next day. So with the crushing to be completed, it would take about 3 of 8 hour working days.

h) What are the actions (strategies) taken to reduce cycle time?

Increase machines and manpower

3.3. Unnecessary Transportation

i) Briefly explain about internal and external transportation use in the site.

Use Methods	**Approximate distance**	**Is there any possibility of reducing distance?**	**If there is a possibility, how to reduce?**
Internal transportation			
1.Blasted rock transportation from quarry to crusher plant.	*100 m*	No	
2.Crushed aggregate transport from crusher stock pile to selected temporary stock piles.	*100-200m*	Yes	Increase the crusher space
3.Diesel transportation from Diesel tank to generator	*60m*	No	
4.Explosive material transportation from site magazine to quarry	*100-300m*	No	
5.Site watering by Water bowser	*2 Km*	No	
External transportation			
1.Explosive transportation from supplier to site	*35Km*	No	
2.Production delivery from site to construction site.	*Vary with site location*	No	

3.Diesel transportation from nearest fuel station to site	*12Km*	No	
4.Material transportation from nearest town centers to site	*23Km*	No	
5.Transportation of damaged parts of machines and vehicles from site to company main workshop.	*60Km*	Yes	Install a proper workshop inside the site premises.

j) Are there any delays in above transportation methods?

No

k) If there is a delay what are the reasons?

N/A

l) Propose actions/ strategies/ suggestions to reduce delays?

N/A

m) Is there any intermediate storages/ double handling occasions?

Yes, there is double handling

n) If yes, what are the reasons for double handling?

Jaw of the original crusher broke down and as an instant solution used the mobile jaw crusher of the company. However the capacity of the primary crusher (mobile crusher) is double the capacity of the secondary crusher.

Also due to the less space of the crusher stock piles, we have to stock excess production in selected temporary stock piles.

o) Is there any possibility of reducing double handling?

Yes

p) If there is a possibility, How to reduce?

Increase the crusher stockpiling space or change the crusher layout.

3.4. Unnecessary processing

g) What is the average time required and currently taking time for each stage?

Stage	**Qty**	**Average time required**	**Actual time**
Drilling	*12 feet hole*	*15 -20 min*	*15-20 min*
Charging & Blasting	*60 holes*	*2 hr*	*2 ½ hr*
Mucking, Scaling &Braking			
Loading	*3 cube*	*6 min*	*10 min*
Transporting			
Processing/ Crushing		*300 cubes per day*	*270cubes per day*

h) If above times do not tally with each other, what is the reason for that?

Charging and blasting can be quickened if more workers are used. And in the case of loading the increased time is due to the unskilled workers. Bore holes fill with water also cause to increase the charging time. And for processing wearing of the machine is the reason for reduced capacity.

i) What kind of strategies can be taken to tally these times?

By requiting required number of skill workers.

Also currently use crusher plant is almost 75 years old. So now it is time to sell this and install a new plant.

j) If above times are tally with each other, what kind of strategies are already used?

Workers engaged in drilling operations are highly experienced.

k) Are there any inappropriate production/ processing steps in this site?

No, all steps are necessary

l) If yes, do you have taken any actions (strategies) to eliminate those?

N/A

3.5. Excess Inventories

d) What is the minimum required and currently use of inventories to achieve present demand?

	Item	Minimum requirement	Current availability
Machineries			
1.	Rock drilling machine/ Track drilling machine	*3*	*3*
2.	Air Compressor	*4*	*3*
3.	Excavator	*4*	*4*
4.	Breaker	*2*	*2*
5.	Loader	*1*	*1*
6.	Exploder	*1*	*1*
7.	Dump trucks	*3*	*2*
8.	Double cab/ Jeep	*1*	*1*
9.	Vibrating feeder	*1*	*1*
10.	Jaw crusher	*1*	*1*
11.	Cone crusher/ Impact crusher	*1*	*1*
12.	Vibrating screen	*2*	*2*
13.	Generator	*1*	*1*
14.	Water bowser	*1*	*1*
15.	Any other	-	-
Material			
1.	Drill bits		Normally keep one week stock and maintain material check list to identify the availability.
2.	Drill rods		
3.	Ammonium Nitrate		
4.	Dynamite/ Water gel		
5.	Electric/ Plane detonators		
6.	Fuel		
7.	Grease		
8.	Hydraulic Oil		
9.	Engine oil		
10.	Any other		

e) If above numbers do not tally with each other, what is the reason for that?

While three air compressors are being used in operations, a fourth one is needed as a standby to use in any emergency situation.

Also, there is a Volvo 5.5 cubes dump truck for rock transport from quarry to crusher plant, but its capacity and fuel consumption are very high. This is also better unnecessary one and enough to use 3cubes dump trucks (2 nos.).

f) Do you have any actions/ strategies to keep minimum requirement?

Air compressors are supplied by subcontractors. So whenever a breakdown occurs, I inform the subcontractor and he immediately replaces it with a good one.

3.6. Unnecessary Movement/Motion

	Exploitation / Quarrying stage		**Processing / Crushing stage**	
	Machinery Movements	**Human Motions**	**Machinery Movements**	**Human Motions**
Types				
Are there any unnecessary……..? (Eg: Turning, Lifting, Reaching, Traveling/ looking for parts, tools, helps, etc.)	Yes	Yes	No	Yes
If yes, What are those?	*Unnecessary traveling of excavators when mucking start in the wrong side.*	*During a machine maintenance workers move from site to store several times for looking tools, parts and materials*		*at the time of crusher plant repairing, some operators, mechanics and helpers traveled from crusher site to store several times*

What are the reasons for these movements/ motions?	*Misinformation*	No separate tool box for machines, not use record books		*Not initially identifying reason for the breakdown and not using of record book.*
Is there any possibility to reduce these movements/ motions?	Yes	Yes		Yes
If yes, what are the strategies taken to reduce?	*Set up a proper flow for site information*	*List out the tools needed for the maintenance and bring them at once. Should maintain a proper record of materials, tools need*		List out the tools and materials needed after properly identify the issue and bring them at once. *Also we don't have a store keeper to maintain store well and if it is maintained properly*

3.7. Defects

m) Which production categories are demanded by the customers?
ABC, Asphalt aggregates, Concrete aggregate, C1 and Boulders

n) What are the quality requirements expected by the customers in each category? *Specially sample size, grading of the sample, AIV and LAAV*

o) What actions are currently taking to maintain relevant qualities?
Sieve analysis test is caring out tow vise a day for each stock pile in crusher plant to check the sample size and grading of the sample. If there any

changes we do corrective actions immediately. Also crusher settings are check every day before stat the crushing activities.

p) How to eliminate the adding of foreign materials / impurities to the production?

Before start the drilling activities, all overburden soil and weathered rock layers are removed properly by using excavators and manually as per the site condition.

q) Is there any possibility to arise quality issues in production? Yes

r) If yes, what are those? and what actions (strategies) can be taken to eliminate these issues?

If we checked the crusher settings daily, those can be vary suddenly. Because it depends on the mechanical system and hydraulic pressure. Also our crusher plant now very old. Therefore can occur changes of sample size and grading.

Damage of sieves in screen can be happen any time and it also cause to arise quality issues. Uneven loading also cause to quality issues. Therefore close monitoring and supervision is important. Also maintain check list to do relevant changes and mentainenace as necessarily can be applied.

Also small particles like dust (0-5mm size) settle down on the stock pile due to raining. Sometimes dust can be removed from the pile with rain water stream. In this type of situation grading of the sample can be completely change, but this issue cannot be avoided due to the aggregate mining industry is an open environment business.

s) Is there any possibility to reject the productions due to poor quality?*Yes*

t) Has your organization faced to that type of occasions? *Yes*

u) If your organization would have to face these types of occasions, how to handle rejected productions?

Two months before we supplied our ABC to one road construction project. After we supplied around 1000cubes to their, they said its sample grading is little bit change their expectations. Then we mobilized our mobile crusher to their and crushed again in same location.

v) Is there any scrap production in your site? *Yes, but some times*

w) If yes, do you have any suggestions (strategies) to minimize this scrap production?

Sometimes scrap crusher production can be happened due to customer demand mix design does not tally with crusher production. Actually, it cannot be avoidable. So it is difficult to give any suggestions to minimize it.

x) Do you think that any repairs of machines and/ or plant is a solution for maintain production quality?

Yes. Our crusher plant is now very old. So crusher variation and breakdown has happen normally. So it is necessary to do full repair or installation of new crusher plant.

3.8. Underutilized people

n) What are the minimum required and currently using employees for each stage to achieve present demand?

Stage	**Minimum requirement**	**Actual availability**
Drilling	*9*	*9*
Charging & Blasting	*10*	*7*
Mucking, Scaling & Braking	*9*	*7*
Loading	*5*	*5*
Transporting	*5*	*5*
Processing/ Crushing	*14*	*12*

o) If above numbers do not tally with each other, what is the reason for that?

The company does not hire enough workers. For blasting operation, foreman should be there. But I do not have any truest in hired foremen and the company also does not have any policy in recruiting foramens.

p) Do you have any actions/ strategies to keep minimum requirement?

Only the action is hiring required employees.

q) Has each employee got target to achieve? Please explain those?

No individual targets are given. Only an overall project target i.e. to complete 9,000 tons of boulders by April 8.

r) Do you have any employee controlling process to reach their targets?

No controlling process. Have a friendly employer – employee working relationship. It's enough to explain about the required work to be done. The worker does it to his best.

s) Do you have any monitoring program to compare performance against targets?

No monitoring program. Just casually take that 12 loads of 15 tons per day is enough to achieve target.

t) How are their performances?

Performance is in satisfactory level. It is enough to mention about the requirement.

u) If they cannot achieve their targets, what are the reasons for that? What type of corrective actions can be taken? *N/A*

v) If they can achieve their targets, which methods can be implemented to increase the progress of work?

It is better if the company can give them a bonus for achieving targets.

w) Does this business culture de-motivate the employees?

Yes it is.

x) If yes, please explain the situation?

Once the company gave a difficult target to achieve. But the employees work hard and achieve the target somehow. But the said bonus was not given still for two months. Also even though these employees work hard all day, they are not satisfied with the salary. On the other hand the company is a well-known one. But if outsider comes into the site, he cannot even recognize the office. Also accommodations of workers are within the site hence it gives an unpleasant look for the working environment with cloths hanging around the site. Also it is unhygienic for the workers because they have to live the dust.

Site safety also not satisfied. It should be improved in all areas. Initially awareness program should be conducted due to lack of knowledge about safety in every one. Also cannot be satisfied about the safety sign boards in

the site. Also there are no fire extinguishers placed in the site and no any trained person about fire protection. Also our explosive magazine is not in a proper location. It is installed much closed to the office premises. Even the top management was informed about that but they do not expect to remove it to a safety location.

y) As you believe, is this project use their employee creativity, physical skills and abilities in success to reach to the project goal?
Employee creativity is not being used. But their physical skills are properly identified and let them work accordingly.

z) Please explain those situations?
The company does not have any talent building policy. On the other hand all employees are given an overall training on every site work. Hence every worker is able to perform every work in the site.

ANNEX C