

CHAPTER 2 - LITERATURE REVIEW

In this literature review, matters related to cement industry overview, raw material mining, technical operation aspect of quarry and financing schemes that suitable for the solution will be explained.

2.1 Indonesia Cement Industry

The cement industry in Indonesia is currently experiencing very heavy pressure. Previously, cement players in Indonesia were only 9 brand : Semen Gresik, Semen Padang, Semen Tonasa, Semen Baturaja, Semen Andalas Aceh which members of the Semen Indonesia Group (SIG) holding as state-owned enterprises, also there were a number of private cement companies Indocement, Bosowa, Kupang cement and Holcim. However, since 2015 many cement brands have entered and set up factories in Indonesia and the majority are from China: Conch cement, Hongshui (singa merah), Juishin, Siam cement, Puger cement, Grobogan cement, Semeru Surya cement, Java cement, Bima cement and cement Jakarta. And the latest is Kobexindo cement in East Kutai, East Kalimantan. This causes national cement factory over capacity which is the demand only 54% of the installed capacity, thus causing price wars and market cannibalization.



Fig 2.1 Cement Manufacturer in Indonesia

Refer to fig 2.1 cement manufacturer in Indonesia (source : internal and Indonesian Cement Association) , that China brand cement factories are spread throughout Indonesia from West Java to Papua. Throughout 2022, cement from China has contributed 17% of national cement production capacity, namely CONCH cement, HONGSHI cement & JUI SHIN. The presence of Chinese cement has resulted in tight price competition. And over the last 5 years, due to this competition, a number of cement companies have experienced a decline in return on assets (RoA), which previously averaged 11-19%, now experienced a decline only 1-7%.

Apart from that, the market is also very sensitive to current turmoil, because 70% of the cement market in Indonesia is retail, 30% are medium and large scale infrastructure projects. In fact, in several cases, especially Q1 & Q2 2023, macro indicators are quite stable and better than 2022 but demand is 6.5% lower yoy 2023 than 2022. So that the cement manufacturers struggling to carry out cost efficiency programs. Starting from distribution and logistics costs, energy costs, raw material mining costs and of course increasing throughput productivity of factory (Source : Indonesia Cement Association & Earning Call Report H1 2023 Indocement Tunggal Perkasa).

2.1.1 Cement Manufacture Process

The cement production process can be divided into (http://en.wikipedia.org/wiki/Portland_cement) :

1. Wet process.

In the wet process all existing raw materials are mixed with water, crushed and evaporated then burned using fuel oil, burn (bunker crude oil). Currently this process is rarely used due to problems limited fuel energy.

2. Dry process

In the dry process, grinding and blending techniques are used, then burned with coal fire. This process includes five management stages that is :

1. The process of drying and grinding raw materials in rotary dryers and roller meal.
2. Mixing process (homogenizing raw meal) to obtain homogeneous mixture.

3. The process of burning raw meal to produce slag (clinker: material semi-finished product required for cement production).
4. Slag cooling process.
5. Final grinding process in which clinker and gypsum are ground with cement mill.

From the cement making process above, evaporation will occur due to combustion at temperatures reaching 900 degrees Celsius.

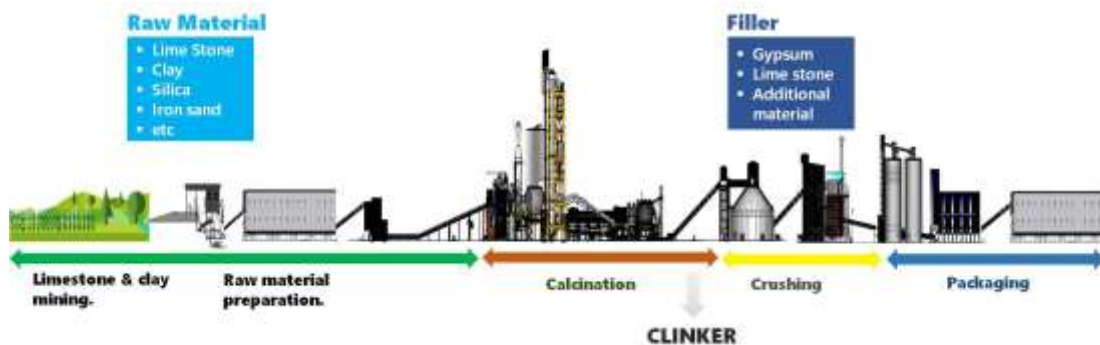


Fig 2.2 Cement process manufacture

Refer to fig 2.2 cement process manufacture in general, the cement production process goes through 5 stages, namely:

1. Mining quarry and storage of raw materials.

The most common cement, namely portland cement, requires four the main chemical components to obtain the chemical composition appropriate. These materials are chalk (limestone), silica (silica sand), alumina (clay), and iron oxide (iron ore). Gypsum in large quantities a little is added during grinding to slow down hardening.

2. Grinding and mixing of raw materials preparation.

All raw materials are crushed to a fine powder and mixed to get Homogenization of raw materials before entering the combustion process.

3. Calcination/Burning.

The most complicated stage in portland cement production is the process Combustion for calcination, where a chemical conversion process occurs according to design and physical process for preparing a mixture of raw materials to form clinker. This process is carried out in a rotary kiln using Fossil fuels can be solid

(coal), liquid (diesel), or fuel alternative. Coal is the most commonly used fuel due to cost considerations.

4. Grinding/Crushing of combustion products

The next process is smoothing the clinker with a little addition gypsum, less than 4%, to produce portland cement type 1. Other type of cements are produced by adding pozzolan or stone additives lime in cement grinding.

4. Cooling and packing.

2.2 Raw Material Mining Process

Limestone extraction is carried out by mining using heavy equipment and also involve explosives. The stages of limestone mining are:

1. Striping/clearing, namely stripping or opening the crust layer from the top layer of hill to obtain a layer of limestone using bulldozer.
2. Boring/drilling, namely drilling using a crawler drill and drill master with compressed air power from a compressor. This 4.5-5.5 inch diameter metal drill was intended to implant explosives.
3. Blasting, namely the blasting process using dynamite and mixing materials in the form of ammonium nitrate and fuel oil (ANFO).
4. Breaking and Dozing, namely the process of collecting limestone that has been blasted using a dozer and then breaking into smaller size for certain bigger boulder.
5. Loading, is the process of transporting limestone material resulting from blasting using an excavator onto a dump truck.
6. Hauling, is the process of transporting limestone from the mining location, in this case the Karang Putih, to the designated factory crusher.

This process is carried out directly in the mining area, illustrated as follow :

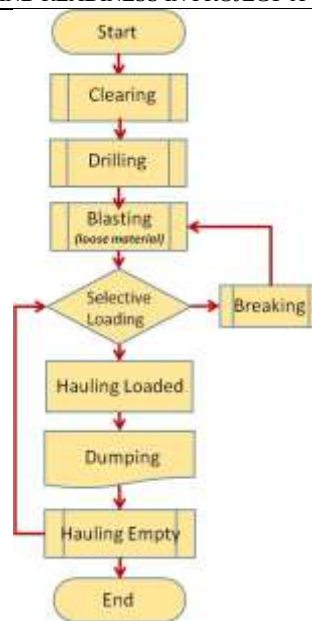


Fig 2.3 Limestone Mining process flowchart

From the flowchart fig 2.3 limestone mining process, in West Sumatra project mining activities requires some model of heavy equipment: bulldozer Komatsu D85ESS-2, motor grader Komatsu GD535, compactor Bomag BW211D, drilling Furukawa HCR 1500, excavator Komatsu PC400, Komatsu PC300 and dump truck Scania P360. Each machine's role has been explained according to the explanation above previously.

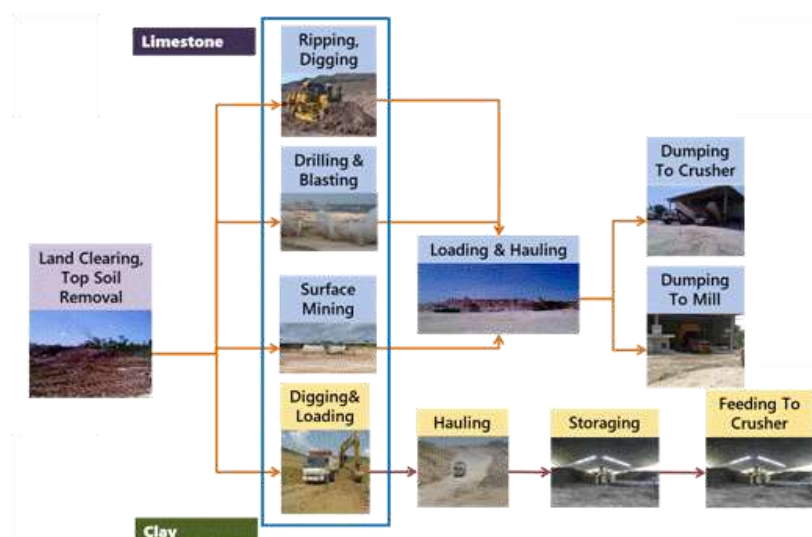


Fig 2.4 Heavy equipment involve in Mining process

Refer to fig 2.4 heavy equipment involve in mining process, the core process in mining activity is loading and hauling, because the biggest mining costs: operators, fuel, investment and maintenance are in this core process. The others process can say as supporting job, but however the cost and productivity still need to be controlled precisely also.

2.2.1 Loading and hauling at Project-X

Loading is the activity of loading blasted limestone with a maximum size of 80 cm onto transportation equipment. The mechanical heavy equipment required is an excavator with a maximum bucket capacity of 5 m³. PT XYZ as a quarry contractor will use equipment with this maximum capacity. If there is limestone resulting from blasting with a diameter more than 80 cm, the contractor is obliged to separate the limestone so that it is not transported by means of transportation to the crusher hopper. For the material with size more than 80 cm, it is necessary to break it down with an excavator breaker to a smaller size below 80 cm, this is breaking called as rehandling job. More frequent of rehandling work will result in increased costs.



Fig 2.5 Loading Working Area

Refer to fig 2.5 loading working area, there are 2 working loading area on the project-X : pit PLB as current working area namely as a front, and the next will develop new front working area pit PNPB. PLB pits the distance average 1000 meters, and PNPB pits are an average of 2000 to 4000 m away from the factory's hover crusher. The mechanism for loading the material/overburden/limestone implemented in X-Project of PT XYZ by using a combination of heavy equipment, such as the Komatsu PC300/400 Backhoe then loaded to Scania P360 6x4 DV17 dump truck then dumped to crusher cement factory . In this mechanism begins with the process of drilling and blasting to dismantle the in situ material.

In the activity of loading and hauling loaded material/Overburden/lime stone which greatly affects of working efficiency is the actual time that used by operators for production activities (effective working time). Some time, the available of working hours cannot be fully 100% used for production, due to possible obstacles reduce effective working hours. Usually the ineffectiveness of working hours is many emergence factors in the field :

1. Readiness of heavy equipment, its means the reliability of the fleet.
2. Time constraints (Loss time), such as human factor Start Operation, Stop Operation, Start Rest Time, Stop Rest time.
3. Factor Equipment compatibility (match factor), In here can be minimized so that the matching factor can manage.
4. Working condition : narrow of front area, gradability of hauling road and rolling resistance of road.
5. Skill operator, working in mining area need high skill and safety awareness to get optimal production.
6. Weather, when rainy session the road more slippery and when dry session very dusty. And all those condition will impact on the cycle time, safety and productivity.

In project-X, the contractor is also responsible for preventing materials that have the potential to interfere with crusher operations, namely: drill rods, drill bits, excavator bucket teeth and other metal materials from mining equipment.

But for the clay mining preparation the manufacturer buy from other parties/vendor. But basically clay mining is almost the same as limestone mining, only without the

drilling and blasting process. The stages are: clearing, stripping, digging-loading and hauling to clay storage near factory.

2.3 Time Motion Study

Motion study was first introduced by Frank and Lilian Gilbreth is a study of the movements and efforts carried out by workers with the aim of eliminating waste. Time and Motion Study (TMS) is defined as a method to determine the ‘correct time’, it takes to complete a certain task. A method to establish ‘the one best way to perform a task (Rebecca Johnstone, Dr Foster, 2014). TMS intended to eliminate ‘goofing off’ and to establish appropriate constituted working hours. Motion study is also used to develop new methods, correct ineffective ways of working, to analyze processes and operations, and to develop combinations between humans and machines for production activities. According to Marvin E. Mundel, the terms time and motion itself can be interpreted in two ways, namely:

a. Motion study.

The motion study aspect consists of description, systematic analysis and development of work methods in determining raw materials, output design, process, work tools, work place, and equipment for each step in a process, human activity that carries out each activity itself. The purpose of the motion study method is to determine or design a method appropriate work to complete an activity.

b. Time study.

The main aspect of time study consists of a variety of procedures for determine the length of time needed using time measurement standards defined, for each activity involving humans, machines or a combination activities (Ciptani, 2008).

According to Yuliarto (2009), time and motion study can be defined as an approach that guides engineering in selecting a product methods related to designing a desired work station both by the designer and the company.

And Wignjosoebroto (1995) explains that time and motion study is a systematic study of work systems with the aim of developing better systems and methods, standardize systems and standards, determine time standards and train operators.

There are two types of time and motion study measurement techniques, namely:

a. Direct time measurement.

The measurement method is carried out directly, namely by directly observe the work carried out by the operator and take notes the time required by the operator to carry out his work First divide the work operation into elements detailed work perhaps provided it can still be observed and measured. Direct measurement method This can use stopwatch time study and sampling methods work (Work Sampling).

b. Indirect measurement of time.

The way to measure it is by calculating where the working time is the observer is not at the work site being measured. The measurement method is not this directly uses standard time data (Standard Data) and data movement time (Predetermined Time System).

Criteria that must be fulfilled in time and measuring activities motion study is an activity that must be carried out repetitively and uniform, the content or type of work must be homogeneous, the work results (output) must be able to be calculated in real terms (quantitatively) either as a whole or for each elements of work in progress and the work is sufficient widely implemented and regular in nature so that it will be adequate to measure and calculated the standard time (Wignjosoebroto, 1995).

To obtain optimal results, carry out time and motion study measurements must consider many factors including working conditions, measurement method, number of work cycles being measured (University Kristen Petra, 2009).

1. Initial preparation for the Time and Motion Study test.

The initial preparation for the time and motion study test aims to learn working conditions and methods and then take corrective steps as well standardize it. This standardization of working conditions and methods is known as movement studies (motion studies). Apart from preparing working conditions and methods Steps are also needed in selecting the operator who will carry out the work that will be measured. The operator selected should have normal skills so that after obtaining the standard time it can be followed by an average other operators (Wignjosoebroto, 1995).

The main equipment used in time and motion study tests is stop watch (Stopwatch), other than a stopwatch, a work measurement support tool, namely observation sheet

which functions to record all information related to the work operations being measured (Petra Christian University, 2009).

2. Elemental Breakdown (Division of Operations into Elements Work).

Before carrying out a time and motion study test, it is necessary first to divide operations into elements more detailed work. Therefore there are three rules that need to be known and followed, namely:

- a. Elements work is made as detailed and short as possible, but still allows it to be measured accurately.
- b. Handling time such as loading and unloading must be separated from machining time. This handling consists of work which is done by manual by the operator and absolutely concentrated work measurement activities here because it will then be related to the issue of performance rating.
- c. Elements constant work and variable work elements must be separated. The constant work elements are the elements which is free from the influence of the size, weight, length or shape of the workpiece being made (Petra Christian University, 2009).

3. Observation and Measurement.

According to Petra Christian University (2009) there are three methods used to measure elements work using a stopwatch, ie continuous time measurement (continuous timing), time measurement repeatedly (repetitive timing or snap back method) and measurement time in addition (accumulative timing).



Fig 2.6 Hauling Road Project-X for TMS

Refer to fig 2.6 hauling road project-X become the target to measure of time motion study. The length of the distance will vary from 1000 to 4000 m which will depend on the active crusher and pit areas, but basically the hauling road goes through that road. This is a 2 way traffic direction but not in the all weather road category because it requires maintenance, especially during the rainy season. When the truck is loaded, the road is downhill, but when it is empty the road is uphill for the entire distance. The road slope angle or gradability varies and the highest reaches 16.5%, meaning this slope grade is very extreme and heavy for all types of dump trucks. Basically with TMS is to make sure that the job being evaluated does not include any unnecessary motion to minimize waste time.

In TMS we will do several things to collect data:

1. Field Observation (Front, Hauling Road, Disposal, & Crusher Area).
2. Road Profile Analysis.
3. Unit Performance Analysis by Simulation Vehicle Optimizer (VO).
4. Calculation & Recommendation for Optimum Fleet (OFR).

2.4 Optimum Fleet Recommendation

A decision for selecting and purchasing new mining or quarry equipment must usually be made without the luxury of a pre-test. They sometimes only benchmark other projects and practically calculate productivity based on secondary data only without going through in-depth study. Practically, it only considers the bucket size of the loading equipment combined with the vessel volume of the hauling equipment and compared with the target rate. Without considering field operation factors, operator skills, road conditions, work load conditions and several aspects that affect equipment productivity.

Engineering PT XYZ, customer and Application Engineers principal can provide accurate simulations to assist the company to conduct optimum fleet recommendation (OFR). The OFR is to ensure that the company select the right equipment to suit their specific job requirements to achieve their target productivity precisely, on time, on budget and on schedule. OFR will consider the data parameters that influences of the production, primary data : gradability, rolling resistance, slope, owning cost, operating cost, travel rate, cycle time, job efficiency, etc. and secondary data :

technical specification of equipment (bucket size, vessel size, swing speed), phases number, machine price, parts price, etc.

With OFR the company will get many benefit :

1. Maximize the reliability and durability of their equipment
2. Improve fleet performance
3. Minimize machine downtime

The stages in calculating OFR are as follows:

1. Customer data, this data consist of : production target, material specification (density), swelling factor, hauling distance, shift roster and effective working hours.
2. Customer productivity, the dimension of productivity very wide and variety because this data needed to calculate the productivity of fleet. The data consist of : specification of machine (excavator and dump truck) namely machine model, attachment capacity, productivity of each machine model, cycle time primary and secondary, hauling distance, travel time, loading time, truck speed, physical availability, utilization hours, number per cycle (hauling rate), fleet number and matching factor.
3. Production of unit cost, this units cost consist of operating cost and owning cost for each models.
4. Operating cost, consist of fuel cost, maintenance and repair cost during certain life time target, and operator wages. To calculate this cost the company required the fuel consumption of machine (litre/hours) and fuel price. To calculate the maintenance and repair cost, the company need references what is the maintenance method that company take : preventive, predictive and corrective. And than calculate the cost during life time operation devide by target operating hours during that life.
5. Owning cost, consist of unit price to calculate the depreciation & wright down value and interest rate.

2.5 Productivity Review

When reviewing the performance of a mining or construction project, the most important and crucial thing is how to get the right calculations. Because based on

experience, there is always a difference in mind set between project owners and project implementers. Especially in determining index variables based on field observations. The project owner wants it to be as ideal as possible while the project executor is adjusted to the facts on the ground. So one approach to the solution is to find a reference that is the middle point and conduct a field survey together. The first step in imagining production is to calculate the theoretical value as explained below. These theoretical values are then adjusted to actual figures obtained from similar experiences in the past operation. Based on these numbers (especially work efficiency figures) it will be possible to determine values suitable for projects that are not too optimistic or extravagant. Therefore, it is necessary to understand the theoretical calculations first and be able to obtain the numbers for work efficiency that may be carried out at the work site. From this a realistic picture of the volume of work that can be achieved can be obtained.

2.5.1 Production Calculation Method

It is usual to express the production of construction machines in terms of production per hour (m³/h or cu.yd./h).

This is basically calculated from the volume hauling per cycle, and the number of cycles.

$$Q = q \times N \times E = q \times \left(\frac{60}{Cm} \right) \times E$$

Where :

Q : Hourly production (m³/hr; yd³/hr)

Cm : Cycle time (in minutes)

q : Production (m³; yd³) per cycle, of loose, excavated soil

E : Job efficiency (see the item 2)

(This is determined by the machine capacity.)

N : Number of cycles per hour = (60/Cm)

2.5.1.1 Production Calculation Excavator

The following is a formula for calculating the productivity of an excavator as a loading machine which is calculated for construction application due to machine size :

$$Q = q \times \frac{3600}{Cm} \times E$$

$$= [q1 \times K] \times \frac{3600}{Cm} \times E$$

where :

Q : Hourly production (m³ /hr; yd³ /hr)

q : Production per cycle (m³; yd³)

Cm : Cycle time (sec.)

E : Job efficiency

Production per cycle (q)

$$q = q1 \times k$$

where :

q1: Bucket capacity (heaped) (m³; yd³)

K : Bucket fill factor

Bucket fill factor (K) varies depends on the nature of material. A suitable factor can be selected from table below, taking into consideration the excavation conditions.

Bucket fill factor (Backhoe)		
Up to PC2000	Excavating conditions	Bucket fill factor
Easy	Excavating natural ground of clayey soil, clay, or soft soil	1.1 ~ 1.2
Average	Excavating natural ground of soil such as sandy soil and dry soil	1.0 ~ 1.1
Rather difficult	Excavating natural ground of sandy soil with gravel	0.8 ~ 0.9
Difficult	Loading blasted rock	0.7 ~ 0.8

Bucket fill factor (Loading shovel)		
Up to PC2000	Excavating conditions	Bucket fill factor
Easy	Loading clayey soil, clay, or soft soil	1.0 ~ 1.1
Average	Loading loose soil with small diameter gravel	0.95 ~ 1.0
Rather difficult	Loading well blasted rock	0.90 ~ 0.95
Difficult	Loading poorly blasted rock	0.85 ~ 0.90

Table 2.1 Bucket fill factor for Backhoe & Shovel model

Refer to table 2.1 bucket fill factor for backhoe and shovel, bucket fill factor is a constant determined by the factory. In determining the number of constant according

to the conditions or material being worked on, of course an expert in the field. There are 4 levels of categories in determining bucket fill factor : easy, average, rather difficult and difficult. Example of how to read : on a PC300/400 excavator with a backhoe bucket and working on sandy soil or dry soil, the category is average so the bucket fill factor is 0.8-0.9.

Cycle time (Cm in second), the cycle time on an excavator is the time for one work cycle starting from digging to load the material, then lifting the material and swing as far as the position of the dump truck which then pours the load into the vessel and swing again with the bucket empty and ready to digging again.

“Cycle time = Dig-to-load time + loaded-swing time + dump time + empty-swing time”.

Standard cycle time for each model is listed at the following table :

Model	Range	Swing angle	
		45° ~ 90°	90° ~ 180°
PC200, PC210, PC228US		13 ~ 16	16 ~ 19
PC220, PC230, PC240		14 ~ 17	17 ~ 20
PC270, PC290		15 ~ 18	18 ~ 21
PC300, PC350, PC360, PC390		15 ~ 18	18 ~ 21
PC300, PC350, PC360, PC390 [SE]		17 ~ 20	20 ~ 23
PC400, PC450		16 ~ 19	19 ~ 22
PC400, PC450 [SE]		18 ~ 21	21 ~ 24
PC490, PC500		18 ~ 21	21 ~ 24
PC490, PC500 [SE]		20 ~ 23	23 ~ 26
PC600, PC700		17 ~ 20	20 ~ 23
PC600, PC700 [SE]		19 ~ 22	22 ~ 25
PC800, PC850		18 ~ 21	21 ~ 24
PC800, PC850 [SE]		20 ~ 23	23 ~ 26
PC1250		22 ~ 25	25 ~ 28
PC1250 [SF]		24 ~ 27	27 ~ 30
PC2000		24 ~ 27	27 ~ 30

Table 2.2 Standard Cycle Time Backhoe in Second

Refer to table 2.2 standard cycle time backhoe, when the excavator PC300 looping in one full cycle time with the swing angle 45°-90° as dumptruck position they need 15-18 seconds [i].

However, in Komatsu handbook to calculate adjusted cycle time just convert by multiplying using the following formulation and table :

Cycle time = (standard cycle time) × (conversion factor)

Digging condition $\left(\frac{\text{Digging depth}}{\text{Specified max. digging depth}} \right)$	Dumping condition			
	Easy (Dump onto spoil pile)	Normal (Large dump target)	Rather difficult (Small dump target)	Difficult (Small dump target requiring maximum dumping reach)
Below 40%	0.7	0.9	1.1	1.4
40 ~ 75%	0.8	1	1.3	1.6
Over 75%	0.9	1.1	1.5	1.8

Table 2.3 Conversion Factor Excavator

Refer to table 2.3 conversion factor, need engineering or operation expert to determine the conversion factor which suitable with the working condition. By observing the depth of the bucket during penetration or digging conditions we can determine the factor conversion. Namely, if the depth of bucket when digging around 75% and dumping condition is rather difficult (due to material hardness, boulder size, matting position, etc) the factor will be 1.3, so if the standard cycle time is 18 second [i] , the adjusted cycle time is : $18 \text{ sec} \times 1.3 = 23.4 \text{ seconds}$.

Job efficiency (E) (in typical usage) is a comparison between the time spent working (working time effective), with available working time. Job efficiency listed at the following table for reference. To obtain actual production figure, job efficiency should be determined according to actual operating conditions.

Operating conditions	Job efficiency
Very Good	0.83
Good	0.75
Average	0.67
Rather Poor	0.58

Table 2.4 Job Efficiency Excavator (E)

Refer to table 2.4 job efficiency, in some calculation of efficiency (E), engineers sometimes do not directly use the conversion factors in the table above, but it is still multiplied by others influence factors, namely : skill operator, machine availability and the material condition it self. However, sometimes this is not used because the adjustment factor is too extreme, which results in production adjustments being very low.

2.5.1.2 Production Calculation Dumptruck

The following is a formula for calculating the productivity of a dump truck as a haulage machine :

$$P = C \times \left[\frac{60}{Cmt} \right] \times Et \times M$$

$$= [n \times q1 \times K] \times \left[\frac{60}{Cmt} \right] \times Et \times \left[\frac{Cmt}{n \times Cms} \right]$$

Where :

P : Hourly production (m³/h;yd³/hr)
Et : Job efficiency of dump truck
M : Q'ty of dump trucks in operation
C : Production per-cycle
: C = n × q1 × K

Where :

n : Number of cycles required for loader to fill dump truck
q1 : Bucket capacity of loader (m³, yd³)
K : Bucket fill factor of loader
Cmt : Truck Cycle time

M = Estimating number qty's of trucks required in operation.

= [Cycle time of a dump truck/Loading time]

$$= \left[\frac{Cmt}{n \times Cms} \right]$$

Where :

n : Number of cycles required for a loader to fill a dump truck
Cms : Loader's cycle time (min)
Cmt : Truck's cycle time (min)

Et : Job efficiency (in typical usage) is listed at the following table for reference. To obtain actual production figure, job efficiency should be determined according to actual operating conditions.

Operating conditions	Job efficiency
Good	0.83
Average	0.80
Rather poor	0.75
Poor	0.70

Table 2.5 Job Efficiency for Truck (Et)

Refer to table 2.5 job efficiency dumptruck, the index number different with excavator or loading equipment due to different some specific parameter influenced.

Cmt : Cycle time of dumptruck, is the travel time required for a dump truck starting from positioning the dump truck at the front to be ready to fill it by loader or excavator until it is full, then traveling in a filled condition according to the rated payload until pouring the load into the crusher hover/dumping area and returning empty to the location of the front loader again. The cycle time of a dump truck consists of the following factors :

- (1) Time required for loader to fill dump truck.
- (2) Hauling time
- (3) Time required for unloading (dumping) plus time expended for standby until unloading is started.
- (4) Time required for returning.
- (5) Time required for dump truck to be positioned for loading and for the loader to start loading.

Accordingly, the cycle time = (1) + (2) + (3) + (4) + (5)

$$Cmt = Cms \times (n - 1) + ts + \left(\frac{D}{V1}\right) + t1 + \left(\frac{D}{V2}\right) + t2$$

(1) (2) (3) (4) (5)

- (1) : Loading time
- (2) : Hauling time
- (3) : Dumping time
- (4) : Returning time
- (5) : Spot and delay time

where :

n : Number of passes required for loader to fill dump truck

$$n = C1 / \left(\frac{q1}{K}\right)$$

C1 : Rated capacity or Vessel capacity of dump truck (m^3 , yd^3)

q1 : Bucket capacity of loader (m^3 , yd^3)

K : Bucket fill factor of loader

Cms: Cycle time of loader per-pass (min)

ts : Time required for 1st pass loading.

D : Hauling distance of dump truck (m, yd)

V1 : Average speed of loaded truck travel (m/min, yd/min)

V2 : Average speed of empty truck travel (m/min, yd/min)

t1 : Time required for dumping + time required for standby until dumping is started (min)

t2 : Time required for truck to be positioned and for loader to start loading (min)

(1) Loading time : Time required for a loader to load a truck can be estimated by the following calculation.

Loading time = Cycle time (Cms) x ([No. of passes to load a truck (n)] - 1) + 1st pass loading time (ts)

No. of passes to load a truck (n), the truck's payload depends on body capacity or weight (load) can be carried.

Payload determined by weight :

$$n = \frac{\text{Dump truck Maximum Payload (tonne.tom)}}{\text{Bucket Capacity (M}^3, \text{yd}^3) \times \text{Bucket Fill Factor} \times \text{Loose Dencity}}$$

Payload determined by volume :

$$n = \frac{\text{Dump body Capacity (M}^3, \text{yd}^3)}{\text{Bucket Capacity (M}^3, \text{yd}^3) \times \text{Bucket Fill Factor}}$$

(2) Hauling/Travel time (Loaded-travel time/Haul Time and Empty-travel time/Return Time) : Time taken to haul a load and return empty, can be calculated by dividing haul road into sections according to rolling resistance and grade resistance, as explained below.

(2.a) Rolling resistance and grade resistance : haul road is divided into several sections based on rolling resistance and grade resistance. All of rolling resistance and grade resistance values then to be summed up, resulting in total resistance at each

section. Rolling resistance for each road conditions can be selected by referring to following table.

Road conditions	Rolling resistance
Well-maintained road, surface is flat and firm, properly wetted, and does not sink under weight of vehicle	2%
Same road conditions as above, but surface sinks slightly under weight of vehicle	3.5%
Poorly maintained, not wetted, sinks under weight of vehicle	5.0%
Badly maintained, road base not compacted or stabilized, forms ruts easily	8.0%
Loose sand or gravel road	10.0%
Not maintained at all, soft, muddy, deeply rutted	15 to 20%

Table 2.6 Determined Rolling Resistance

Rolling resistance, sometimes called rolling friction or rolling drag, is the force resisting the motion when a body (such as a ball, tire, or wheel) rolls on a surface. It is mainly caused by non-elastic effects; that is, not all the energy needed for deformation (or movement) of the wheel, roadbed, etc., is recovered when the pressure is removed. Grade resistance can be obtained by averaging the gradients in all sections, converted from degrees to percent (listed at following table).

Grade resistance (%) converted from angle (°) of gradient					
Angle	% (sin α)	Angle	% (sin α)	Angle	% (sin α)
1	1.8	11	19.0	21	35.8
2	3.5	12	20.8	22	37.5
3	5.2	13	22.5	23	39.1
4	7.0	14	24.2	24	40.2
5	8.7	15	25.9	25	42.3
6	10.5	16	27.6	26	43.8
7	12.2	17	29.2	27	45.4
8	13.9	18	30.9	28	47.0
9	15.6	19	32.6	29	48.5

Table 2.7 Determined Grade Resistance from Angle Slope

(2.b) Selecting travel speed : speed range and maximum speed suited to the resistance can be estimated using Travel Performance Curve, usually included in specification sheet. Steps to get truck travel speed using Travel Performance Curve is listed as follow :

- Draw a vertical line from Gross Weight axis (A), then mark point (B) according to total resistance (rolling resistance + grade resistance).
- Draw a horizontal line from (B), then mark (C) where the line intersects the rimpull curve and read (E) for the rimpull.
- Draw a vertical line downward from (C), and read the travel speed at point (D).

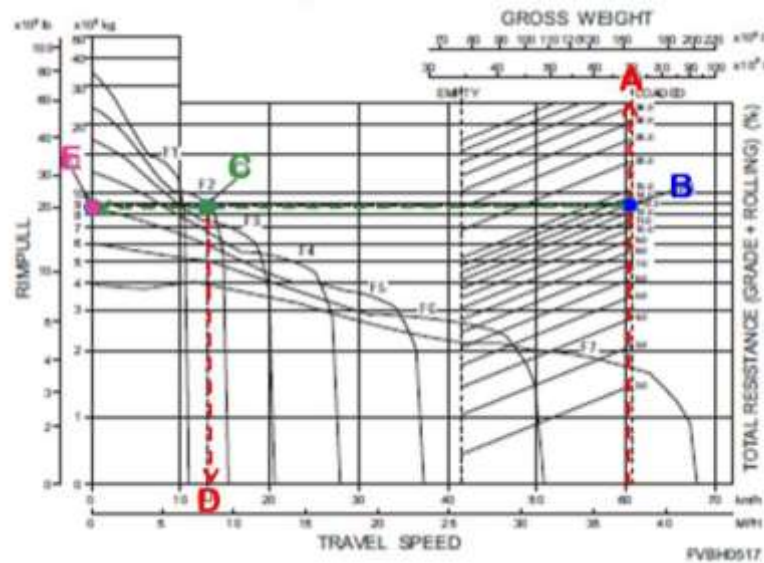


Fig 2.7 Travel Performance Curve

Refer to fig 2.7 travel performance curve, is used to determine the ideal speed according to the conditions of rolling resistance and grade resistance. In the Project-X mining safety regulations, the maximum speed permitted is 50 km/hour on the hauling road.

Using step (i) to (iii), if a truck with 70 tonnes gross weight traveling at a section with 7,5% gradient and 5,5% rolling resistance (total resistance 13%), the rimpull will be around 9 tonnes and travel speed will be 13 km/h at F2.

Maximum speed obtained here is a theoretical value and it should be multiplied by speed factor listed at following reference-table to obtain more-practical average speed.

Road- Section Distance (m)	When making a standing start	When running into each section
0 ~ 100	0.25 ~ 0.50	0.50 ~ 0.70
100 ~ 250	0.35 ~ 0.60	0.60 ~ 0.75
250 ~ 500	0.50 ~ 0.65	0.70 ~ 0.80
500 ~ 750	0.60 ~ 0.70	0.75 ~ 0.80
750 ~ 1000	0.65 ~ 0.75	0.80 ~ 0.85
1000 ~	0.70 ~ 0.85	0.80 ~ 0.90

Table 2.8 Speed Factor

Refer to table 2.9 speed factor, selecting speed factor : technically a truck can reach desired speed faster (short-time) when at a downhill section. In such condition, a higher speed factor should be accounted to the calculation. On the other condition, a

truck will have more difficulty to reach desired speed when at uphill section, therefore a lower speed factor should be accounted to the calculation. Based on above explanation, average speed can be estimated by the following formula :

Average speed = Maximum vehicle speed (obtained from travel performance curve) x Speed factor.

Average speed mentioned above is applicable for common road (driving) conditions. If there any other factor reduce vehicle speed, an applicable factor should be added to the calculation. The following can be referred as factors reducing travel speed.

These factors should be eliminated wherever possible.

- a. Trucks passing each other on a narrow road
- b. Sharp curve or many curves at haul road
- c. Poor visibility points or section
- d. Narrow bridges, railway crossings, road intersections
- e. Sudden and frequent change on rolling resistance
- f. Pot-holes on the road
- g. Un-experienced or unskilled operators

(2.c) Haul time, If each section distance divided by average speed (given in the preceding paragraph), haul time in each section can be estimated. By summing-up these times (haul and return), the total travel time (haul + return time) can be calculated.

Haul and return time at each section = [Section Length/Distance (m) : Average speed (m/min.)]

(2.d) Speed limit at downhill sections, vehicle speed calculation described at section a) to c) is valid for traveling at total resistance value greater than or equal to 0%. If total resistance is less than 0%, vehicle speed usually will be limited by retarder function at a certain distance.

Maximum speed for a truck can travel downhill safely can be obtained by referring to Brake Performance Curve, as shown at Fig. II.8 for example. (Continuous Grade Distance).

For example, an assumption was given that total resistance in a section (continuously) is -14% (gradient resistance at -16% and rolling resistance at +2%).

In order to obtain max. speed at this section:

- (i) Draw a vertical line from Gross Weight axis (A), crossing to the line of 14% total resistance (B).
- (ii) Draw a horizontal line from (B) to the left, crossing the stair curve at (C).
- (iii) Draw a vertical line from (C), and then read point (D) to get maximum speed at downhill section.

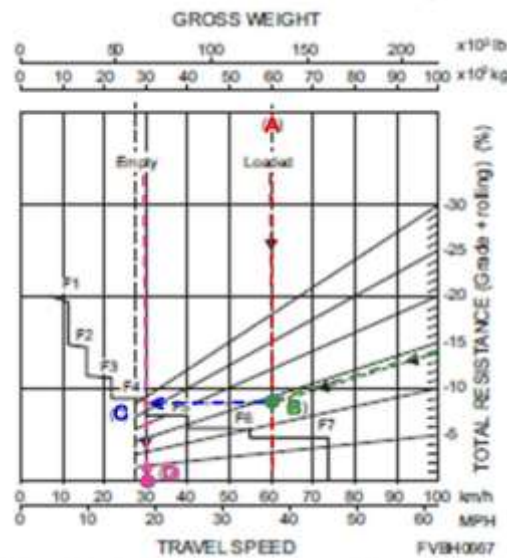


Fig 2.8 Example of Brake Performance Curve(Continuous Grade Distance)

Using step (i) to (iii), the truck mentioned (at the performance curve) should travel at 4th gear with speed around 30km/h (18.6 mph).

(3) Dump time, dump time is refers to time starts when a truck come into dumping area and ends when the truck starts return trip after dumping the material. Since the length of dump time depends on operation condition, the figures listed on the following table can be used for reference for each condition, with factors causing unnecessarily-long dump time excluded.

Operating conditions	t_d , min.
Favorable	0.5 ~ 0.7
Average	1.0 ~ 1.3
Unfavorable	1.5 ~ 2.0

Table 2.9 Dump time

Refer to table 2.9 dump time, is just for references. If the time more than that need to clear and clean up dumping area.

(4) Spotting time, spotting time refers to time for a truck to move into loading position (until loader start to dump first pass). Length of spotting time depends on operation condition, and table 2.10 below can be used for reference at general condition.

Operating conditions	t_s , (min.)
Favorable	0.1 ~ 0.2
Average	0.25 ~ 0.35
Unfavorable	0.4 ~ 0.5

Table 2.10 Spotting time

Truck's total cycle time (Cmt) can be calculated by adding all the values obtained according to explanation at section (1) to (4).

When trucks and loaders used in pairs, the most ideal condition is that trucks' productivity equals to loader's capacity, a condition satisfying the following equation.

$$C \times \left(\frac{60}{Cmt} \right) \times Et \times M \geq q1 \times K \times \left(\frac{60}{Cms} \right) \times Es$$

where :

Cms : Loader's Cycle Time (min)

Es : Loader's Job Efficiency

q1 : Bucket Capacity, heaped (m³; yd³)

K : Bucket fill factor

If the left equation's value is larger, trucks' capacity has some surplus. On the other hand, if the right equation's value is larger, loader's capacity has some surplus.

The matching factor calculation also can use the following formula :

$$MF = \frac{Cm \ DT}{N \times n \times Cm \ EXC}$$

$$N = \frac{Cm \ DT}{n \times Cm \ EXC}$$

Where :

MF = Matching factor

Cm DT = Cycle time Dump Truck (sec)

Cm Exc = Cycle time Excavator (sec)

N = Number of Truck need (unit)

n = Num Cycle of Excavator loading to 1 DT

2.5 Vehicle Optimizer

Vehicle Optimizer (VO) is a software application developed by the Scania company to assist customers in selecting dump truck specifications in order fit to operational conditions and meet to production targets so as to achieve a high level of efficiency and the most efficient costs. So it is necessary to enter data into the VO application software.

The data consist of :

A. Machine specifications :

A.1 Component Powertrain (horse power, ratio, front axle, rear axle, etc).

A.2 Machine Dimension (width, length, gross weight, net weight, turning radius etc).

A.3 Attachments (Vessel, fuel tanks, tyres, rims, spare wheel carrier, loads, electrical choices, trailers, body work etc).

B. Operation Conditions :

B.1 Rated Payload.

B.2 Hauling Distance.

B.3 Cruising speed has been designed.

B.4 Rolling Resistance hauling road.

B.5 Gradient Distribution.

B.6 Frequency of Stop & Go (how often it occurs).

B.7 Weight on the axle and its distribution.



Fig 2.9 Vehicle Optimizer Interface

Refer to fig 2.9 Vehicle Optimizer interface, that the workspace in VO is basically split in two parts, the “Specification area” and the “Information area” as shown in the image above.

The final result of a VO is that with an operating condition such as the project-X, is it appropriate for the selection of the model and type of dump truck equipment that will be used. In terms of the ability to downhill when truck in the rated payload still in a good speed and safety, of course still has sufficient ability in the braking process to control machine. And have capability in good speed to climb uphill toward the front area when return empty.

2.7 Financial Institution

As we know the source of development financing did not only come from banks. Apart from banking, the government also relies on funds from various sources, including foreign cooperation, technical and financial assistance, as well as internal funding from state revenues such as taxes and other levies. In an effort to drive economic and social development, the government uses various sources of financing to support development efforts in various sectors.

Herewith the regulation that serve as a legal reference in Indonesia :

1. Law number 4 of 2023 (UU No 4 2023). Base on BPK web <https://peraturan.bpk.go.id/Details/240203/uu-no-4-tahun-2023>, this law regulates the financial sector ecosystem which includes: 1) the institutions; 2) banking; 3) Capital Market, Money Market and Foreign Exchange Market; 4) insurance and

- guarantee; 5) Joint Business insurance; 6) policy guarantee program; 7) Financing Services Business; 8) bullion business activities; 9) Pension Funds, old age security programs and pension programs; 10) cooperative activities in the financial services sector; 11) microfinance institutions; 12) Financial Conglomeration; 13) Financial Sector Technology Innovation (ITSK); 14) implementation of Sustainable Finance; 15) Financial Literacy, Financial Inclusion and Consumer Protection; 16) access to financing for Micro, Small and Medium Enterprises; 17) human resources; 18) Financial System Stability; 19) Indonesian export financing institutions; and 20) law enforcement in the financial sector. This law reforms the financial sector by regulating institutions and financial system stability and developing and strengthening the industry.
2. Anti-Money Laundering (APU) Regulations: AML laws in Indonesia require banks to report suspicious transactions and implement measures to prevent money laundering and terrorism financing.
 3. Consumer Protection Regulations: There are also regulations that protect consumer rights in banking transactions, such as regulating interest rates, fees and procedures for resolving disputes.
 4. Presidential Decree No. 61 of 1988 opened up opportunities for a variety of business entities to conduct financing activities as an alternative to provide funds to support the growth of the Indonesian economy. Which includes the business of financial institutions is a lease (leasing), trading securities, factoring, venture capital, consumer finance and cards.
 5. Ministerial decree Finance No. 1251/KMK.013/1988 regarding Terms and Procedures Implementation of Financing Institutions.
- A number of regulations mentioned above are related to the financial scheme that will be used by PT XYZ in providing equipment for production.

2.7.1 PSAK 73

Based on the Statement of Financial Accounting Standards (PSAK) 30, the definition of a lease is an agreement in which the lessor gives the lessee the right to use an asset for a certain period of time (Indonesian Institute of Accountants, 2018). Leasing can be a shortcut for companies that cannot afford to buy an asset as capex due to an

expensive or inadequate of company funds/liquidities. This is often found in various companies in Indonesia. Of course, not all companies carry out policies regarding leasing in accordance with predetermined standards or don't even know about it.

Than PSAK 73 starts to apply to all companies in Indonesia starting in 2020 and replaces PSAK 30/ISAK 8. In PSAK 73, almost all forms of leases are financial leases except for short-term leases less than 1 year and with a low underlying value (Ahalik, 2019). Companies that have properly bookkeeping have to apply PSAK 73 regarding for rent proper and correctly. The impact of the enactment of PSAK 73 on financial statements will be different for each company, but for companies that have large rental/lease contracts it will have a big impact. Rent/lease, which was originally only recognized as general expense, has now been recorded in other forms as expense, assets and liabilities.

The impact of implementing PSAK 73 on the financial performance of service companies listed on the Indonesian Stock Exchange resulted in an increase in assets and liabilities and a decrease in equity, as a result there were ratios that experienced impacts such as an increase in the DER solvency ratio and decrease in ROE profitability ratios (Maulana & Satria, 2021).

Safitri et al. (2019) in his research on the Manufacturing, Mining and Service Industries listed on the IDX concluded that the largest impact of rent-capitalization occurred in the service industry, followed by the mining and manufacturing industries with an average increase from Debt to Asset Ratio (DAR), Debt to Equity (DER) and a decrease in Return on Assets (ROA) and Return on Equity (ROE). The treatment PSAK 73 (lease) in the accounting mechanism is "On balance sheet" operating lease without option to transfer asset ownership from lessor to lessee.

2.7.2 PSAK 107 IMBT (2021)

Based on PSAK 107, Ijarah is an agreement to transfer use rights (benefits) on an asset within a certain time with rental payments (ujrah) without follow-up by transferring ownership of the asset itself (Dewan Standard Akuntansi Syariah 2020).

Ijarah is a contract for the transfer of usage rights a good or service, in payment of rental/lease (ujrah), without being followed by transfer of ownership of the goods (Salman 2012). In the context of Syariah banking, ijarah is a lease contract under a

bank or financial institution to lease the machine (equipment), a building or goods, to customers based on a predetermined fee.

There are 3 types of ijarah according to PSAK 107, but which The first two types of ijarah are widely known, namely:

1. Ijarah, an agreement to transfer the use rights (benefits) of an asset or service, within a certain time with payment or rent (ujrah), without di follow with a transfer of ownership of the asset itself.
2. Ijarah Muntahiyah Bittamlik (IMBT) is an ijarah with a contract (promise) from the lessor to transfer of ownership of the ijarah object in the certain time to lessee (customer).

The transfer of ownership will be under new contract is made, which is separate from the previous ijarah contract.

- a. Grants (Hibah)
- b. Sale before the end of contract in an amount proportional to the remaining installments/rent or with price agreed..
- c. Sale at the end of the ijarah period with a certain payment as agreed which is stated in the contract.
- d. Sale in stages at a certain price which agreed in contract.
- e. Sale and lease back, or sale and ijarah transactions. This type of ijarah occurs where someone sells their assets to other parties and resell the asset. Sale and leaseback transactions must be separate and independent transactions (ta'alluq) so that the selling price must be made at fair value and the seller recognizes a gain or loss in the period profit and loss.

Treatment PSAK 107 (2021/IMBT) in the accounting mechanism is "Off balance sheet" operating lease with option to transfer asset ownership from lessor to lessee in the middle or at the end of contract based on agreed price or as a grant with separate new contract. Because IMBT 107 (2021) is off balance sheet, it is only recorded as an rental cost and as account payable only.

Prons & Cons	IMBT	Leasing	Dry Rent	Wet Rent
Periode	5 years	5 years	5 years	5 years
Liquidity requirement	Flexible	Need	No	No
Treatment :				
a. Income Statement	Rent	Depreciation Interest	Depreciation Interest	Rent
b. Balance Sheet	Account Payable	Asset Financing Debt	Asset Lease Debt	Account Payable
c. Regulation PSAK	PSAK 107	PSAK 73	PSAK 73	PSAK 71
Tax treatment	No Correction	Correction	Correction	No Correction
Installement Scheme	Monthly Quarterly Stage-up Repayment	Monthly	Monthly	Monthly

Table 2.11 Comparison The Scheme PSAK 73 with PSAK 107.

Refer to table 2.11 comparison the scheme, compare between financial scheme to fullfillment equipment requirements whether use PSAK 73 or PSAK 107 scheme, which one suitable and fit with PT XYZ covenants.

2.8 Covenants

Covenants are agreements given by borrowers in their loan contracts to limit the borrower's activities or take certain actions aimed at ensuring the creditor's security (Mather and Peirson, 2006). So a covenant is an agreement between two parties that requires or prohibits one party from doing one or more things. In general, covenants are divided into three types, namely affirmative covenants, negative covenants, and financial covenants.

Covenants that determine actions that must be taken are called positive or affirmative covenants, while covenants that determine actions that must not be taken are called negative covenants. Meanwhile, a financial covenant is a financial requirement or limitation regulated in a loan agreement or other financial agreement between the lender (usually a bank or other financial institution) and the borrower (company or individual). These covenants serve as controls or restrictions designed to protect the lender and ensure that the borrower complies with certain conditions during the term of the loan. So PT XYZ with Holding and lenders is bound by a financial covenant.

2.9 DuPont Analysis

DuPont analysis is a framework to analyzing the fundamental of performance which is originally popularized by the DuPont Corporation. Now DuPont analysis widely used to compare the operational efficiency of two similar firms. DuPont analysis is a useful technique used to decompose the different drivers of return on equity/asset (ROE/ROA) (Wayne Pinsent, CFA, 2022). And DuPont analysis very useful technique that used to decompose the different drivers of return on asset (ROA). There are two versions of the analysis, one utilizing decomposing it into 3 steps and another 5 steps. And the company PT XYZ use 3 steps of DuPont analysis.

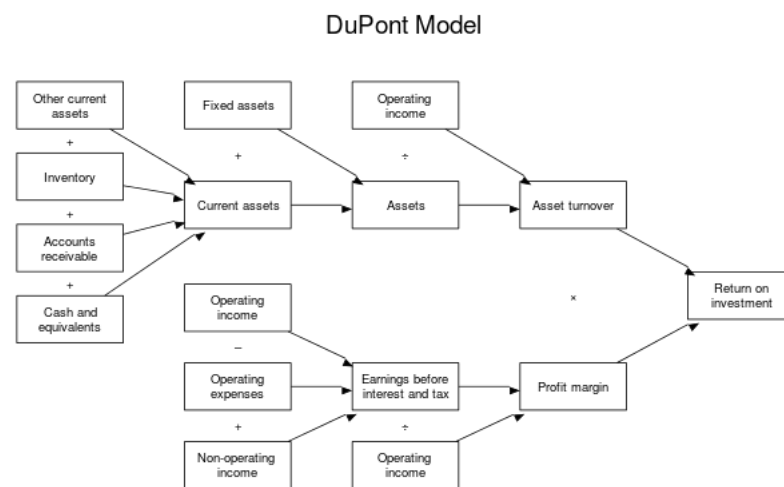


Fig 2.10 DuPont Analysis Model Frame Work

Refer to fig 2.10 DuPont analysis model frame work (source : https://en.wikipedia.org/wiki/DuPont_analysis), the company will use this frame work to identify the impact of development new financial scheme to return on asset. The alternative to improve return on investment are with increase revenue through increase the capacity of production and reduce cost, that may be will impact on the debt and asset.

2.10 Previous Studies

As we stated in chapter I in the significant studies section, there has been several research carried out by previous researchers. However, what we are carrying out is different from that research.

Year	Researcher	Note
2023	Pasisipasi p Tampubolon, Nalom D. Marpaung, dan Rasmi Sitohang	Performance evaluation of loading excavation and transport equipment production achievement at PT Trimata Benua Bentayan village, Tungkil Ilir district, Banyuasin South Sumatra, Vol 18 No 2, Jan 2023.
2021	Akhmad Ryan Dhiya ‘Ulhaq	Literature study regarding the impact of implementing PSAK 73 on fiscal corrections and taxation in Indonesia from tenant's side , 23 Oct 2021
2022	Garyn Arianova Sugiarto; Agung Dinarjito	Analysis of the application of PSAK 73 at PT XYZ, Vol 2 No 2 2022

Table 2.12 Previous Study

Refer to table 2.12 previous study, until this writing was published, we had never had any research studies related to the discussion of IMBT-PSAK 107 (2021) which is used in financing mining production equipment, especially if the discussion is related to ratio covenants. So we compare with PSAK 73 to give overview the comparison in between.