Exploration

- locate aggregate deposit to supply a given market at a competitive price.

- A geologist typically explorations

- A cost analysis of product is extremely important
  - i.) processing
  - ii.) hauling
  - iii.) Sales
  - iv.) regulatory expenses
  - v.) overall profit

- Aggregate Source must meet many physical, mechanical, chemical, and durability properties

- Very few resources are purely homogeneous in aggregates properties

- gradation is extremely important. Too fine of gradation in sand is not desirable

- Beware of outcrops
  - Varying mineral sources in a location
  - Granite outcropping, Limestone cliffs, Sandstone cliffs, Case hardening.

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3-0236 — 100 SHEETS — 5 SQUARES
3-0237 — 200 SHEETS — 5 SQUARES
3-0137 — 200 SHEETS — FILLER
COMET

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3-0137 — 200 SHEETS — FILLER
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Variations in Aggregate Quality

- high variations can create producing and meeting aggregate specifications very difficult and expensive

- Sand & Gravel
  - i.) gradation varies widely
  - ii.) could be unsound due to shale, silstone, & other minerals

- Crushed stone
  - i.) Igneous - porosity and density can vary largely
    - can be highly chemically reactive with Alkalis in cement. (AAR)
  - ii.) Metamorphic - can be very flat in shape due to minerals such as slate, schists, & Gneiss
    - low shear strength due to minerals such as slate
  - iii.) Sedimentary - clay-rich aggregate can retain large amounts of water, which causes expansion
    - shale may be flat, disintegrate upon wetting/drying, sulfate soundness, and freeze-thaw

Exacting

- removal of a substance
- aggregate exacting is a well-thought out process involving:

1.) Design

2.) Planning

3.) Development

4.) Operating

5.) Reclamation

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Extraction of Sand and Gravel

- typically in a loose state, so no need to blast or drill
- uses front-end loaders, power shovels, haul trucks, and bull dozers

Two Types

1.) Dry or dewatered Sources
   - nonsubmerged material pulled out with various construction equiptment

2.) Wet deposit sources
   - water submerged material is removed with a dredge, dragline, or floating cranes
     - dredge - using a bucket excavator or large suction pump
     - dragline - land-based crane that casts buckets into a water
     - floating crane - grab-type bucket suspended on a cable from a boom to obtain material

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Crushed Stone Exaction

- produced from solid rock formations
- exacting involves drilling, blasting, and crushing
- This takes place at a quarry typically

Two Types of Stone Exaction

i.) Surface Mining
ii.) Under ground Mining

*Surface Mining is the most common and will be talked about most here

Surface Mining

1.) Develope of a Quarry
- remove Topsoil and weathered rocks
- Construct haul Road

2.) Drilling and Blasting
- Various drills and explosives are used to break apart rock formations into managable sizes.
- sizes and types of drills & explosives are dependent on thickness, rock hardness, chemical composition, climate, geographical restrictions, and local restrictions

3.) Loading & hauling
- front-end loader or power shovels load aggregate into an off-highway trucks.
- optimum cycle time is very important.
  - loading, hauling, and removing

Designing a Plant

- an experienced plant design engineer must evaluate and formulate a valid design process
- very rugged, massive, and expensive construction equiptment are used in production
- Many parameters Affect Design
  - a.) Mineralogy & Material properties
  - b.) Effects of drilling & blasting on gradation
  - c.) Potential waste products
  - D.) Capital Costs
  - E.) Types of installation - portable, stationary or skid
  - F.) Operating Costs & Criteria
    - Capacity (tons/hr), operating time, percent overtime, electricty (kilo-watt hrs/ton) and weather
  - G.) Maintenance
  - H.) charging plant - truck, loader, excavator
  - I.) Method of stockpiling & storage
  - J.) Method shipping: truck, railroad, barge
  - K.) Space Available
  - L.) Safety
  - M.) Future Growth

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Typical Crushed Rock Plant

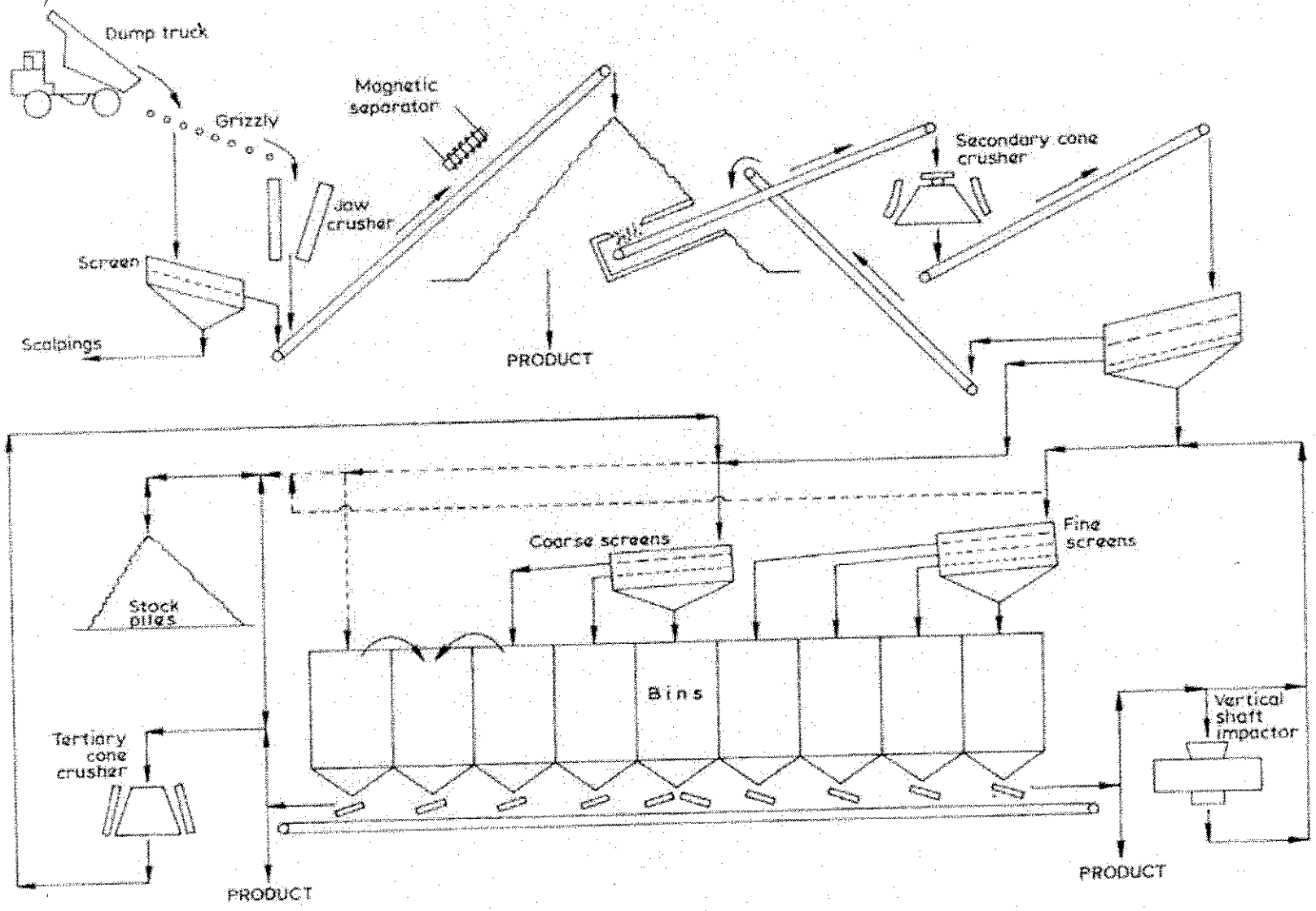

FIG. 5.53. Flowsheet for a typical crushed rock plant.

Sand & Gravel Plant

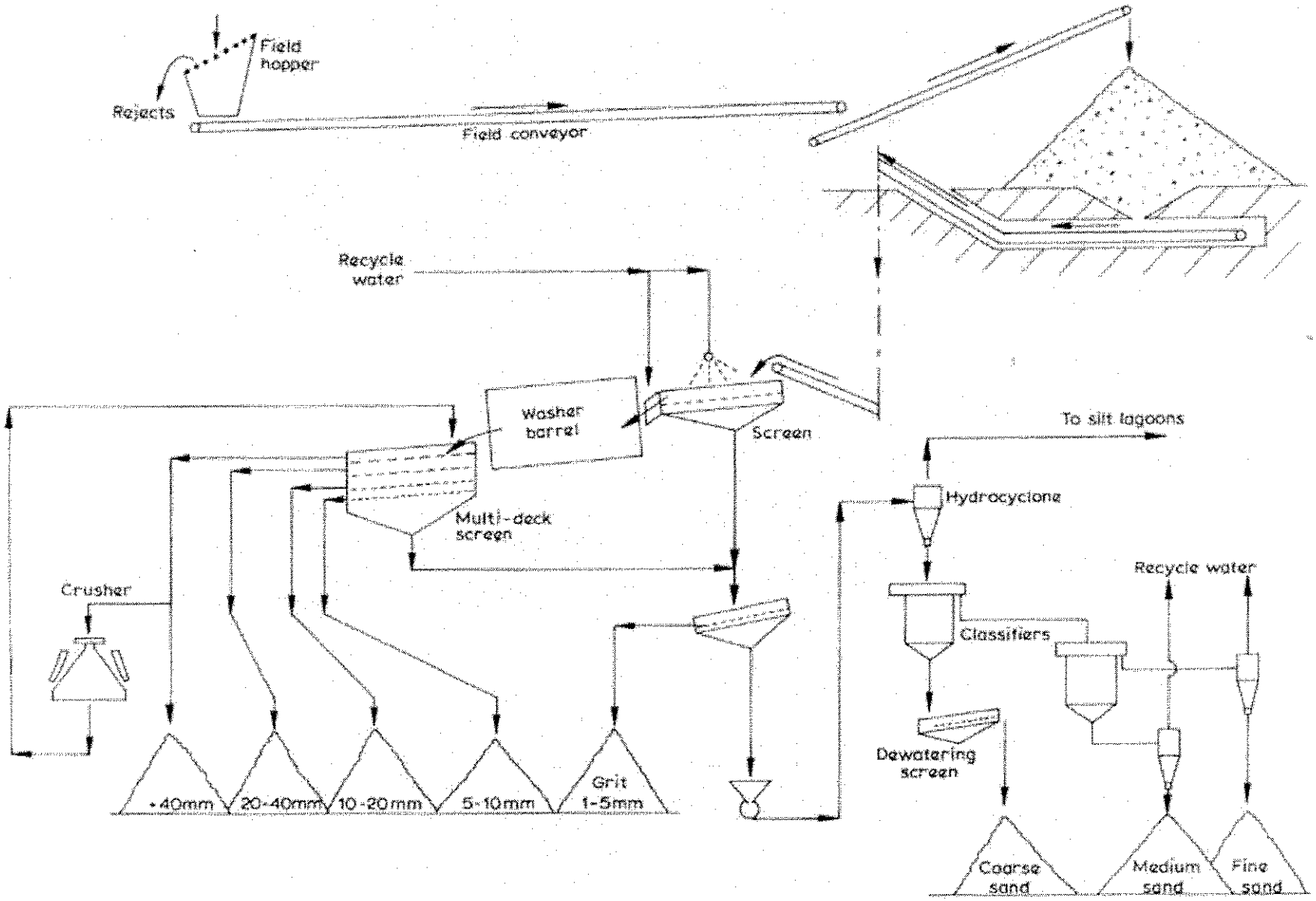

FIG. 5.52. Flowsheet for a typical sand and gravel plant.

Fracture Mechanism of Stone

Stone needs to be fractured by blasting and crushing processes to meet specifications of gradation and shape.

The keys to fracturing stone

1.) Force

2.) Distribution of force

3.) Aggregate characteristics

* A small hammer and chisel can be very effective at reducing the stone size and creating a well shape.

However, a sledge hammer will reduce the size but create more fines and poorer shapes.

3 Mechanisms of Stone Breakage

a.) abrasion – NOT enough energy

b.) Clevage – sufficent energy

c.) Shatter – too much energy

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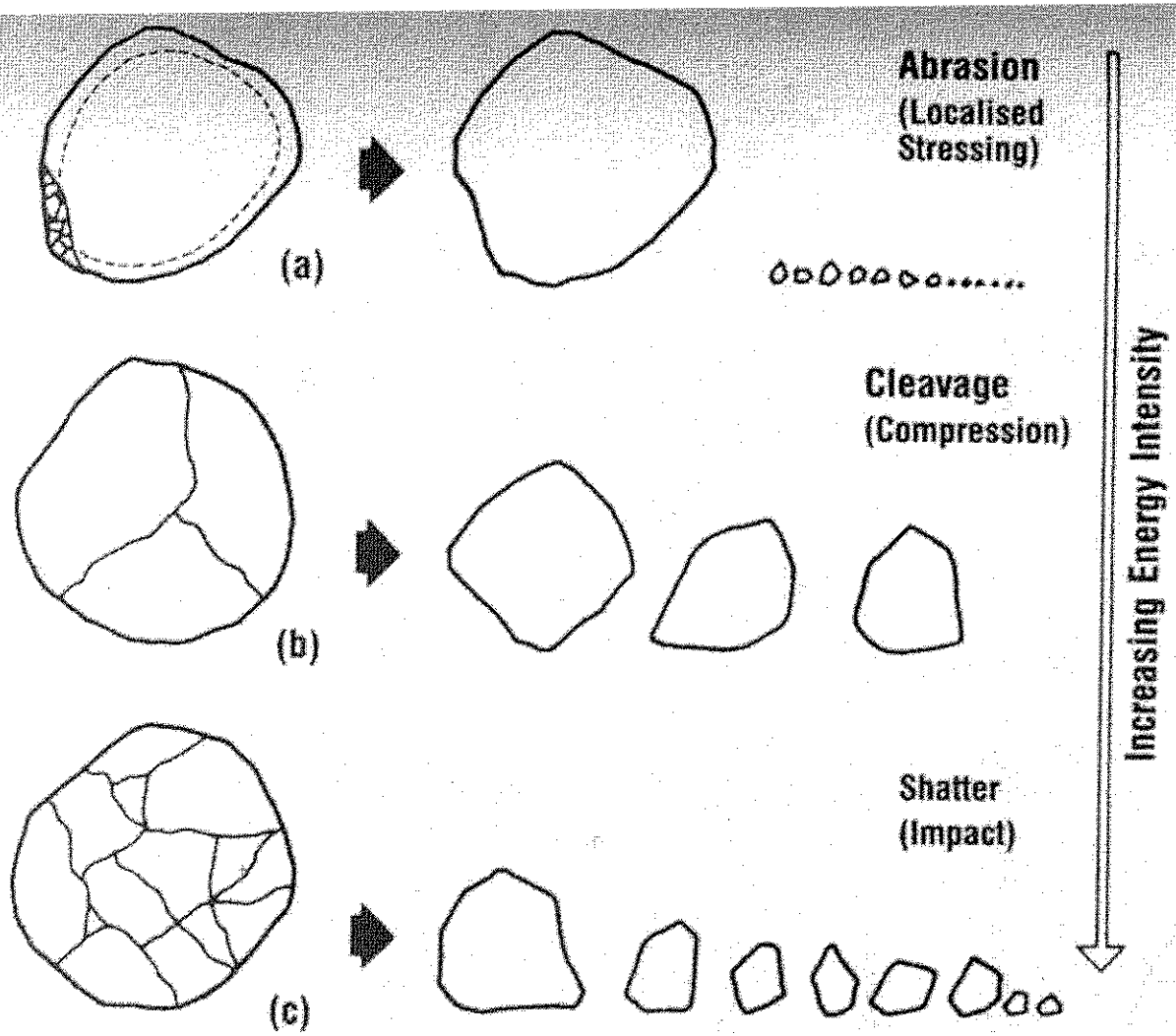

Figure 8.6 Abrasion, clevage and shatter mechanisms of rock breakage.[3]

Abrasion fracture, Figure 8.6(a), occurs when the applied energy is not sufficient to cause significant fracture of the entire particle. Localized stressing occurs and a small area is pulverised to give a distribution of very fine particles.

Cleavage fracture, Figure 8.6(b), occurs when the energy applied is just sufficient to load comparatively few regions of the particle to the fracture point and only a few particles result. Typically this situation occurs under conditions of slow compression where the fracture immediately relieves the loading on the particle.

Fracture by shatter, Figure 8.6(c), occurs when the applied energy is well in excess of that required for cleavage fracture. Under these conditions many areas in the particle are overloaded and the result is a compartively large number of particles with a wide spectrum of sizes.

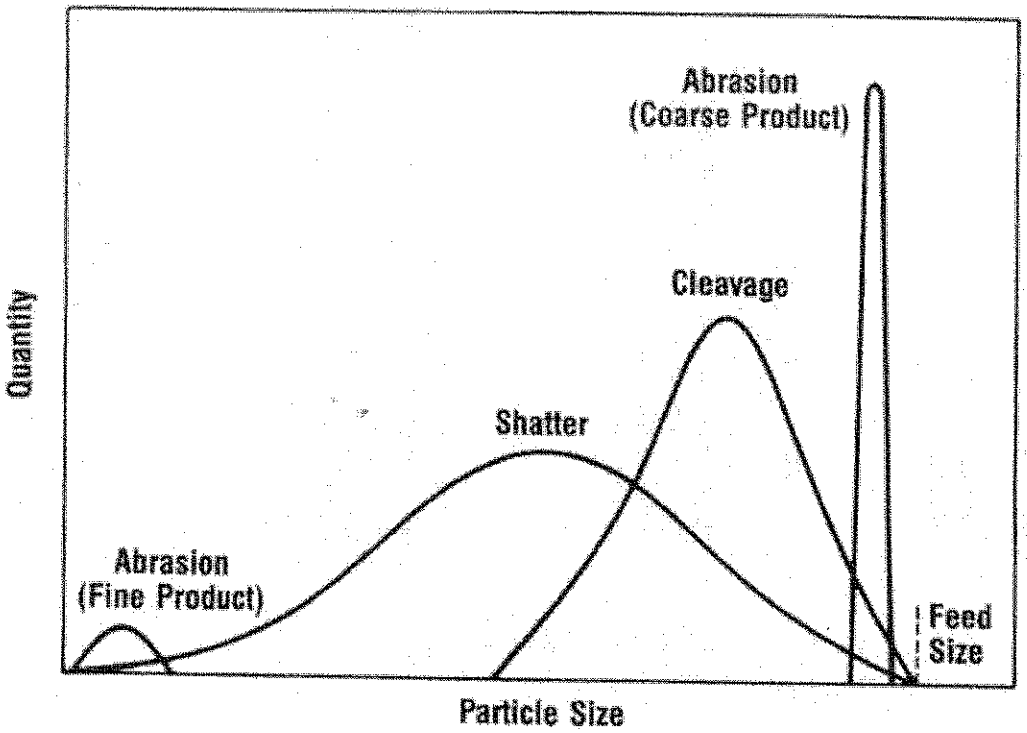

Figure 8.7 Representation of the mechanisms of particle fracture and the resulting product size distributions.[3]

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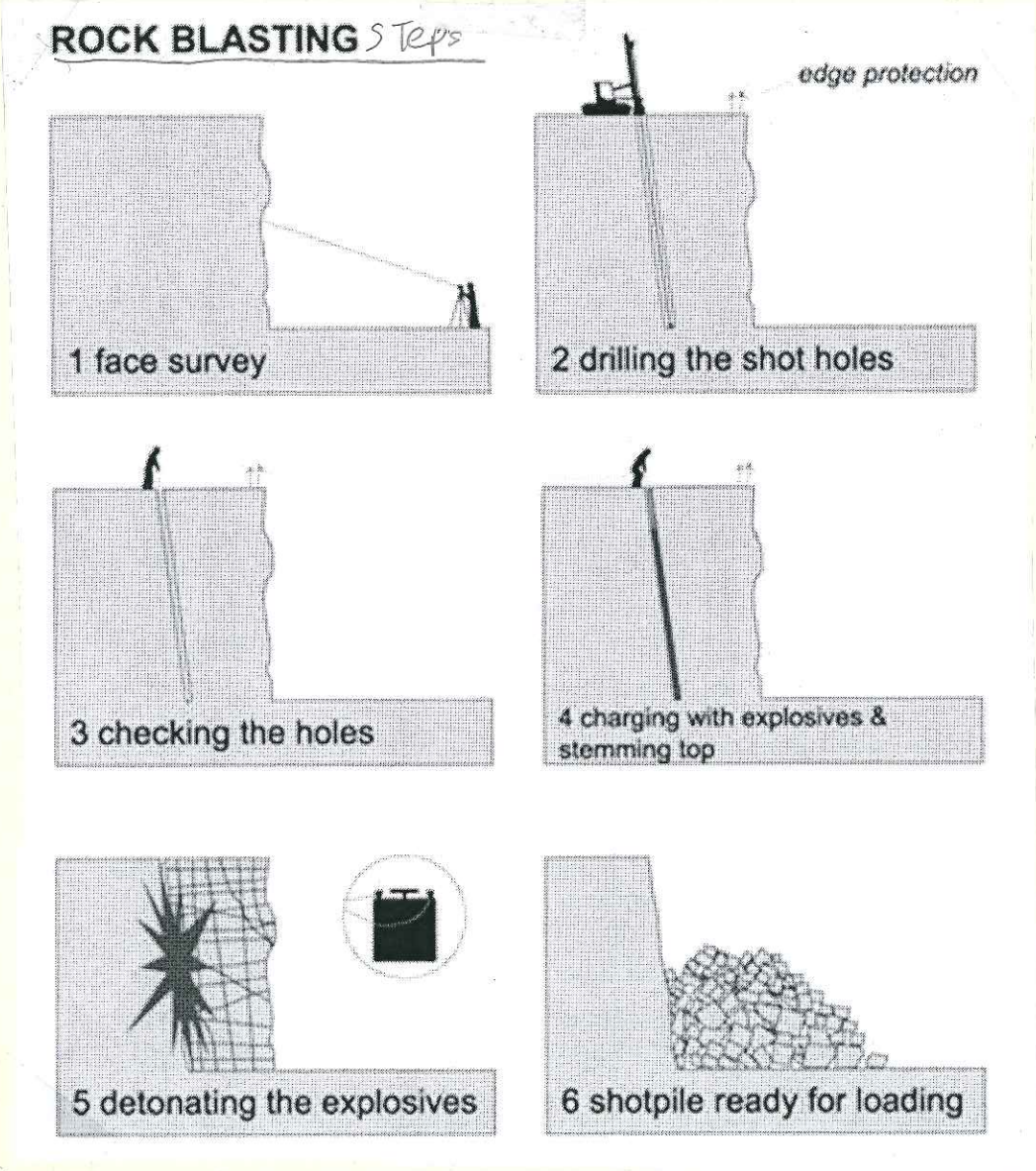
Blasting

- a well-executed blast transforms a solid rock formation into fragments small enough to be accepted by a crusher without excessive fines
- Too much concrentrated force will produce too small of sizes.
- Too little concrentration of force will result in too large of particle sizes to be crushed
- very dangerous
- many safety guidelines have been created.



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3-0137 — 200 SHEETS — FILLER
COMET

Crushing

- Stone is broken into the desired gradation and shape through a series of crushing processes and screens.
- Again, the 3 keys to fracturing are still important to achieve desired gradation and shape, but even more details go into the crushing process.

3 Crushing Factors

1.) Resistance of the material to crushing.

2.) Reduction ratio of the crusher

$$\text{Reduction ratio} = \frac{\text{Size Feed into crusher}}{\text{size product out of crusher}}$$

*Note size is 80% passing a sieve size

3.) Quantity of feed (tons/hr)

3 Stages of crushing

1.) Primary crushing
- reduces large boulders to manageable sizes
- Typically, a jaw or gyratory crusher

2.) Secondary Crushing
- reduces sizes to commerical uses
- Typically, a cone or impact crusher

3.) Tertiary Crushing
- Sometimes used when secondary crusher doesn't achieve desired size and shape.

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3-0137 — 200 SHEETS — FILLER
COMET

3 Types of crushing equiptment

a.) Impact crushers

- exerts high speed blows causing high degree of shatter

b.) Jaw and Gyratory Crushers

- exerts low amounts of energy causing more abrasion and clevage

c.) Cone Crushers

- exerts moderate amounts of energy creating clevage and shatter

Crusher Equiptment Manufactures

- they are selling a product
- However, they can provide charts for predicting the capacity and gradation using their equiptment
- Chart can't take into account the ability of the aggregate type to crusher.

Optimal Feed

- crushing equiptment, especially compression and impact Crushers require interparticle energy transfer to achieve efficient performance

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3-0137 — 200 SHEETS — FILLER
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Screening

- Screening is the process of seperating aggregate particles into various sizes
- various types and layers of screens can be used to efficiently separate particles
- screen capacity, efficiency, and screen bed depth all impact production rate. Formulas can be found in the Aggregates Handbook.
- Aggregate height on screen should not exceed 4 times the screen size opening
- a grizzly is a type of screen for initally separating the muck pile before it enters the primary crusher
- Moisture can also reduce the efficiency of screening

Screening Surface

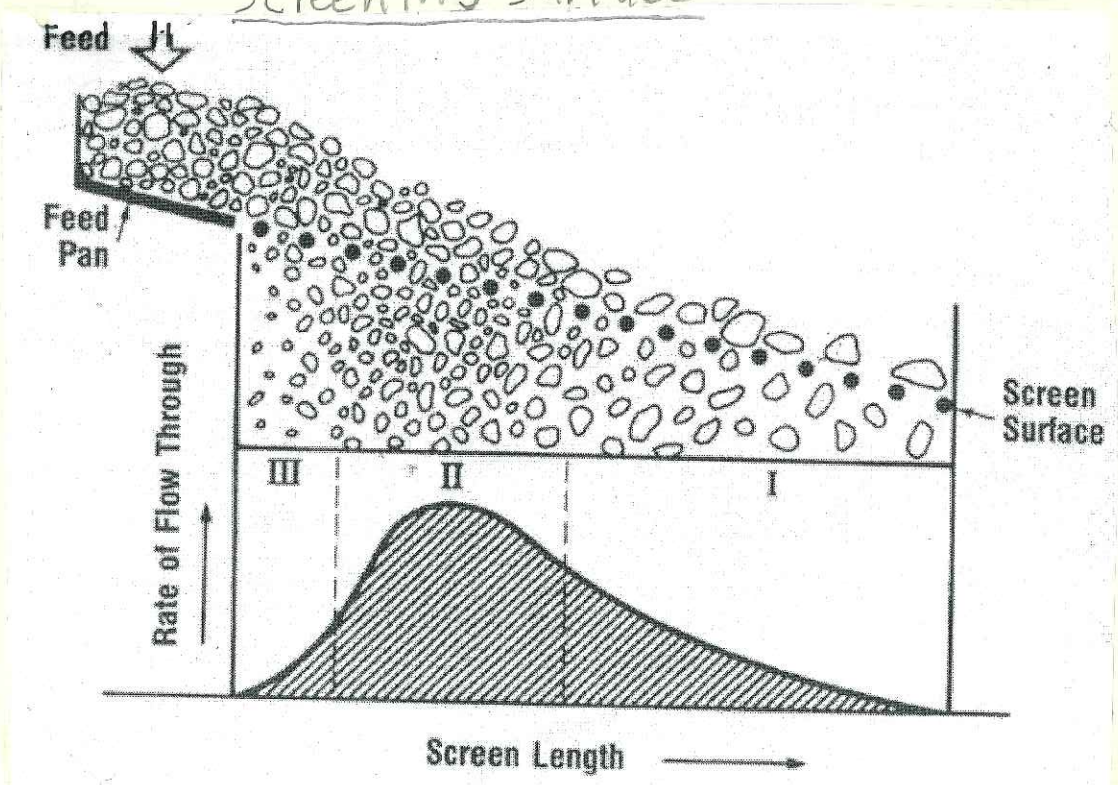

Figure 8.11 The three major regions occurring along a screening surface.[3]

Other Products Produced Indirectly From Crushing

Riprap

- As a muckpile is loaded into a gizzly screen, large stones are rejected from being crushed due to the size. The rejected stones are used for Riprap
- These sizes range from 6 to 30 inches
- They can be used to help protect structures against erosion and scouring.

Manufactured Sand

- This is a by-product from the crushing process
- Sizes can vary from 3/8" to very fine dust
- Screenings is the unwashed by-product that comes directly after the screening (sieving) process. This is many times called unwashed manufactured sand. It is used to help fine grade many aggregate base surfaces.
- Manufactured sand is usually a coarser gradation than many natural sands. This has typically been washed to remove the dust particles.
- a fine Manufactured sand has been recrushed to finer gradations and the dust removed. The gradation will not be as well-distributed as natural sand.
- Depending on the market in the area, cost of production, cost of disposal, and revenue of it, all are variables that go into the decision of producing any of the manufactured sand types.

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Handling of Material into a Gradation

- To move material in an efficient and timely manner during the crushing process, chutes conveyors, elevators, and hoppers can be used.
- Feeders and gates can help monitor the flow.
- After material is crushed and screened into the desired size, it is typically placed into seperate bins. This process is called fractionating.
- To meet a gradation requirement, the aggregate sizes are blended together on a stockpile or truck loadout bins.
- Aggregate may need to be washed to remove excessive fine. Many techniques can be used to accomplish it.

Gradation variation due to plant Preformance

- Maintaining screens
- setting on crushers
- production rate
- gradation into and out of crusher

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Load out

- This is a Term describing the process of transporting the finished product to the customer.
- The product is weighed during loading processes and sold by the ton.
- Then the finished product is discharged into a dump truck, rail car, or a Barge.

Segregation of gradation

- defined as the separation of a particle size from the overall mass.
- This can be caused by handling, Transporting, poor Storage, and large range of gradation
- Producers want a close gradation range to reduce problems with segregation

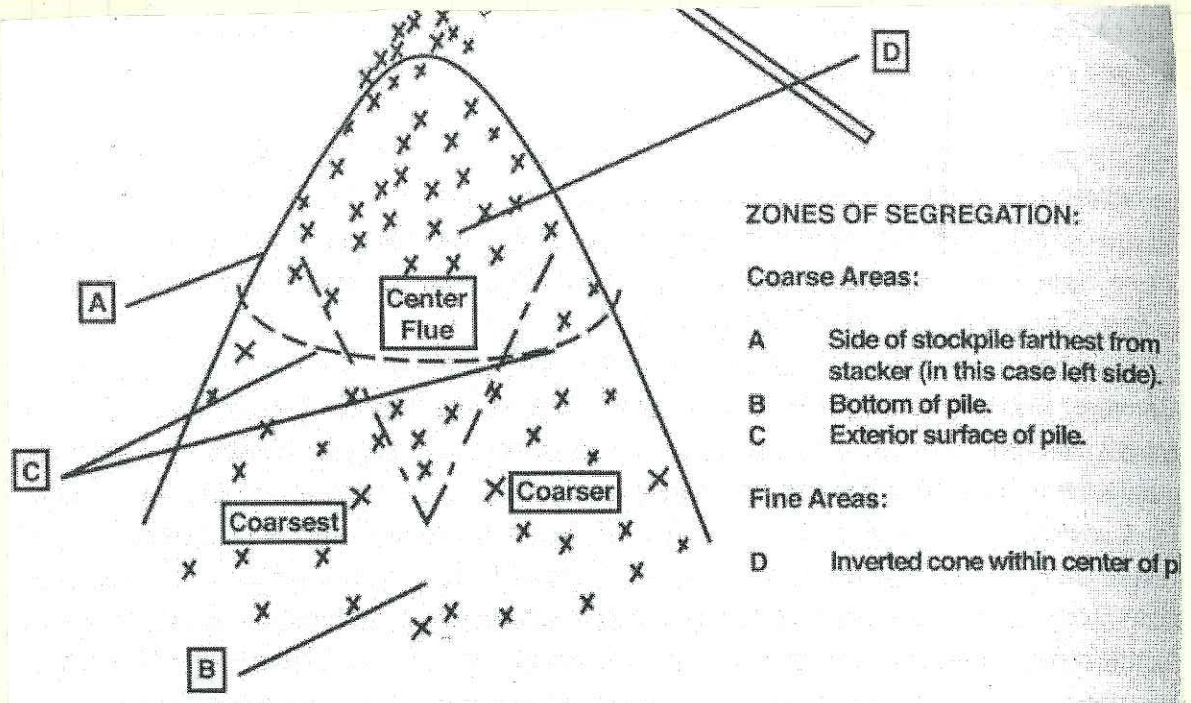

Figure 18.6 Sampling from a Stockpile Formed with a Fixed Conveyor

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Storage in a Drum or Central Batch Plant

- many different methods can be used to store and transport aggregates in an Drum or central batch plant for Asphalt or Concrete.

- The more aggregates are moved, the more prone the aggregates will be to segregate.

- Conveyors drastically reduce segregation compared to front-end loaders.

- The most preferred method to prevent segregation and increase production is to use conveyor belts that places aggregate into storage bins.

- However, many ready-mix plants and temporary asphalt plants will use stockpiles to store aggregate and use a front-end loader to load them.

- Many different bins can be used to meet a gradation.

- It is not unrealistic for an Asphalt pavement to use 6 different gradation bins to meet a combined gradation

- A Ready-mix plant may only have a single sand bin and a single coarse aggregate bin.

Types of Bin Techniques

1.) By sieve-size - For a more precise way to combined a gradation, aggregates are sieved before being placed into bin.

2.) TWO-Bin System - using only a rock bin and a sand bin to meet a combined gradation

3.) Multiple bins - 3 or more aggregate gradations are used. For example, a #57, 3/8" chip, and sand bin