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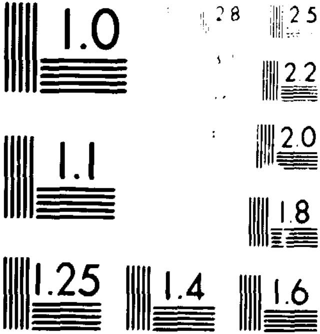
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BACKGROUND PAPER

ESTABLISHING FACTORIES FOR THE PRODUCTION OF LIME-POZZOLANA CEMENT*

(A PRELIMINARY GUIDE)

by

P. Olof Grane**

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1. SUMMARY

Low cost housing has a high priority in many developing countries. One of the more costly items used in construction is portland cement. Consequently the desire is if possible to replace the cement by a cheaper binding agent. Such a more economical binder can be produced from a mixture of slaked lime and an active pozzolana. Natural pozzolanas such as volcanic ashes and trass are quite common, otherwise industrial wastes such as flyash or industrially produced artificial pozzolanas show good results.

Pozzolime produced from trass and used in mortar and rendering plaster shows good bond strength and excellent plastering properties. It can also be used in concrete for foundations and for flooring.

The manufacturing process consists of crushing and drying the pozzolana whereafter it is finely ground in a ball mill together with lime to a fineness of about 75 micron.

Cost estimates for a 40 t/d, 100 t/d and 200 t/d plant with investments from about U$S 0,8 mill, 1,7 mill. and 2,3 mill. show an annual return on investment from (5)% to 30%.

The profitability will naturally vary from country to country, and in each particular case a detailed feasibility study must be made.

2. THE PRODUCT

2.1 Description of the basic product

The basic product is a mixture of finely ground pozzolana and lime hydrate, which in this manual will be called Pozzolime. This mixture has hydraulic properties and when mixed with water to a paste it will harden like portland cement. It can be used as a substitute for portland cement in mortars and also in concrete where no high strength is required. It can be produced in substantially smaller units than portland cement at lower investment cost and is less energy consuming.

Of the two raw materials, lime and pozzolana, the pozzolana can be either natural or artificial while the lime should be a non-dolomitic dry slaked lime hydrate. The two raw materials are ground together in a ball mill in the proportions 1:2-3 by weight and the resulting pozzolime is bagged and distributed in paper bags. If stored more than two months the bags should have an inner lining of polyeten.

3. THE RAW MATERIALS

3.1 Pozzolana: The classical definition of a pozzolana is that it is a siliceous aluminious material which in itself has little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties.

3.1.1. Natural pozzolanas are found in many countries, especially those with recent volcanic activity. Among the first used and best known are the volcanic tuffs from Pozzuoli in Italy and from the island of Santorin in Greece. Others are the Rhenish trass in Germany, the trasses in Java, Indonesia, rhyolitic tuffs and pumicites in USA, diatomite in its various forms as freshwater or saltwater deposits also called kieselguhr, infusorial earth, tripoli, rottenstone, etc. Pumice and lavas also have pozzolanic properties, more or less pronounced. One such pozzolana is the Efate pumice breccia, New Hebrides, another the Djongo Pozzolana in Cameroon. Gaize, which is found in the Ardennes, is a dual type pozzolana, consisting of a clay cemented by gelatinous silica. Particularly when burnt and ground, this material exhibits marked pozzolanic properties. The Danish "moler" or moss-clay is another natural pozzolana of the dual type.

3.1.2. Artificial pozzolanas can be either by-products from industrial activity or intentionally calcined materials. Among the first mentioned and perhaps most prominent is flyash, the residue from coal-fired power stations.

Another industrial by-product useful in the production of hydraulic binders is blastfurnace slag. Spent oil-shale has been used in large quantities for the manufacture of pozzolime in Scotland, Esthonia and Sweden. The Indian surkhi, of course is well known and has been used for centuries in India, and is also used in Indonesia. It is produced from accidentally or voluntarily broken red clay bricks or is manufactured in special kilns 1/ where duly selected clay is calcined at controlled temperature.

Other industrial by-products, similar to flyash, are the ashes obtained when burning agricultural materials such as coffee husks or rice husks. Especially rice husk ash (RHA) is known to have good pozzolanic properties and it is produced in very large quantities in many countries, where it, just like flyash was before, is considered a valueless nuisance. Now when its value has been established as an important raw material for pozzolime, it is expected to be able to contribute considerably to the economy in rural construction. Other ashes obtained from the burning of wood in lime kilns or brick kilns, especially the hardwood ashes, are also said to have pozzolanic properties. The ash from burning of bagasse has proved to be a pozzolana.

3.2 <u>Lime</u>: Lime is, of course, a widely used binder which is produced almost everywhere.2/ The limestone is calcined in kilns which vary from the most primitive ones consisting of a hole in the ground to the most sophisticated installations with very large outputs. The hydrate is manufactured

---

1/ down draught kilns, rotary kilns or fluo-solid kilns.

2/ The raw material is limestone which occurs in different forms such as pure calcite, sedimentary bedded limestone, coral stone, marine shell deposits, etc.

by slaking the burnt lime with water which can be done in a primitive way by sprinkling water on a layer of lime and then turning this over with shovels. It is also done in industrial slakers consisting of single or multi stage horizontal cylinders where the slaking is carried out with precisely controlled amounts of hot water to achieve a complete slaking.

4. IMPORTANCE FOR INDUSTRIAL DEVELOPMENT

The intimate mixture of the two raw materials, the pozzolana and the lime, constitute a cheap but effective hydraulic binder which in many instances can substitute portland cement. The cost price depends on the price of the two raw materials which varies widely. In most countries lime is cheaper than cement while in some it is more expensive. If a natural pozzolana is used the pozzolime is considerably cheaper than cement but if an artificial pozzolana is used the resulting pozzolime may be only slightly cheaper than cement. Thus if a manufacture is based for example on rice husk ash or trass the pozzolime is definitely cheaper than portland cement but if it is based on an artificial pozzolana produced from a difficult to exploit shale or clay deposit it would be only a little cheaper then cement but will still, of course, have the advantage that it can be produced on a small scale, using locally available raw materials and give much needed labour opportunities. As the technological process involved is fairly simple no high degree of skilled labour is necessary.

Product diversification is possible in so far as the pozzolana itself, either natural or artificial, can be dried, ground, bagged and shipped to other parts of the country where it can be mixed with locally burnt and slaked lime, either dry slaked, for further distribution or wet slaked for use on the spot.

5. MARKETING, COMMERCIAL AND REGULATORY ASPECTS

5.1 The market

There always is a ready, potential market for a cheap binder but it is important that a high and uniform quality is maintained through continuous control. As the hardening of a mortar made with pozzolime is slower than such made with portland cement and the compressive strength also is lower though completely sufficient and satisfactory for the uses it is recommended for, once the product has been put on the market it must not be allowed to vary or deteriorate because it can then easily get a bad reputation and nobody will want to use it.

5.2 The competition

The main competition is portland cement but as pozzolime, as has been stated before, generally is cheaper than cement, there should be no difficulty to sell a high quality pozzolime. When used in mortars it is competing also with lime but people will notice that the pozzolime hardens quicker than common lime, it achieves a higher strength and is also to a certain degree water proof. A small plant situated strategically away from a cement plant in a country where no freight compensation system is used, will be able to easily build up a good market for its product.

5.3 Siting the factory

While a small plant can be sited almost anywhere that proper raw materials are available, a larger plant must take due consideration to a number of factors:

(a) availability of suitable natural pozzolana or industrial by-product pozzolana, or availability of raw material for the production of an artificial pozzolana.

(b) availability of lime or lime hydrate or limestone for the production of lime

(c) availability of electric power, natural gas or fuel oil, water

(d) availability of man-power and a certain degree of medium skilled labour

(e) distance to and size of a potential market

5.4 Government assistance

Government assistance could turn out to be the most important factor in the decision taking and this assistance can be required or granted on a number of points:

(a) approval of the product as such and of its use in government construction.

(b) granting of loans through a government agency or guarantee for a loan through private or foreign entities.

(c) granting of tax benefits

(d) abolishing of import duties for foreign make parts of plant machinery

The national benefits, including cheaper housing and provision of more jobs, surely will give cause for government action along those lines.

6. THE FACTORY

6.1 Choice of technology

Most large industrial installations of any kind are generally the result of the development from small scale and even hand-operated outfits. Thus pozzolime can be made by crushing bricks or volcanic aggregates by hand, sieving the product and mixing it with slaked lime, eventually grinding the two together in some sort of mill. This can still be made in a small rural community to find use for the rice husk ash or similar but it is obvious that the quality of such a product cannot be very high and will vary considerably.

India is the country where most pozzolime in any appreciable quantity is used. It is produced under various names, such as "Lime-Reactive surkhi Mixture", "Lympo", "LBCPM" (lime burnt clay pozzolana mixture), etc. A number of papers by the various Indian research institutes have been published on this subject. Most deal with pilot plants or small-scale plants but generally only with the artificial pozzolana producing parts. Industrially operated full-scale plants for readymade pozzolime do not seem to exist. The author therefore has had to design from scratch an industrial pozzolime plant.

The technology involved in the manufacture of pozzolime can be split up in three stages:

I Preparation of the pozzolana
- (a) crushing
- (b) drying or calcining

II Preparation of the lime
- (a) calcining limestone
- (b) hydrating the quicklime

III Intergrinding of the two raw materials

6.1.1 Stage I will have to be carried out differently depending on the raw material to be used. Thus RHA and other ashes, pumicite and fine powdered volcanic ashes will not need any crushing and in some cases perhaps even not drying.

When calcining is necessary, this can be done in various types of kilns. The simplest is the downdraught kiln where the raw material after having been formed into brick form is burnt, but as the time and temperature cannot be regulated this is not a satisfactory way of producing pozzolana. Each type of raw material has a narrow range of temperature at which the optimum pozzolanic property is achieved and this cannot be regulated in a downdraught kiln.

The kiln mostly used for this purpose is the rotary kiln. The heat can be well regulated by the amount of fuel fed to the kiln and both gas as well as fuel oil and coal powder (in which case the ash will constitute an additional pozzolana) can be used. The calcining time which also is of importance can be regulated by varying the inclination of the kiln and its length.

A third type of kiln suitable for the calcination of fine powdered raw materials is the flucsolid kiln in which the material is calcined in dense suspension in a rising current of hot gases. The temperature and the calcining time can be regulated very closely.

6.1.2. Stage II involves the lime burning and slaking. As this in itself is an industry which is very common and slaked lime generally can be purchased any place, it shall only be emphasized that the hydrated lime must be dry, less than 2% moisture, when it is interground with the pozzolana. This can only be achieved in an industrial slaker under rigorous control. Unfortunately industrial slakers generally are quite expensive, sometimes even more costly than the lime kiln. However, if the demand on the quality of the hydrate is not too severe, except for the moisture content, it is not necessary to install a 3-stage hydrator, then a single stage will do.

A single stage hydrator consists mainly of a horizontal cylinder provided with agitators fastened to a horizontal axis and a vertical tower for the pre-heating of the slaking water by using the escaping steam produced in the slaking process and at the same time it will serve as a washing tower for the lime dust.

Another simple but effective enough design is to do the pre-slaking in a screw conveyor and finish the hydration process in a silo placed below. As the hydrated lime shall be ground in a ball mill with the pozzolana no air classifier is needed at this stage. Important is that the installation is provided with control instruments for the control of the amount of lime and the amount of water.

As a dry, hydrated lime is essential, the three types of slakers are briefly specified and illustrated.

a) <u>3-stage hydrator, type KLD, capacity 5 t/h</u>. Fig. No. 1.

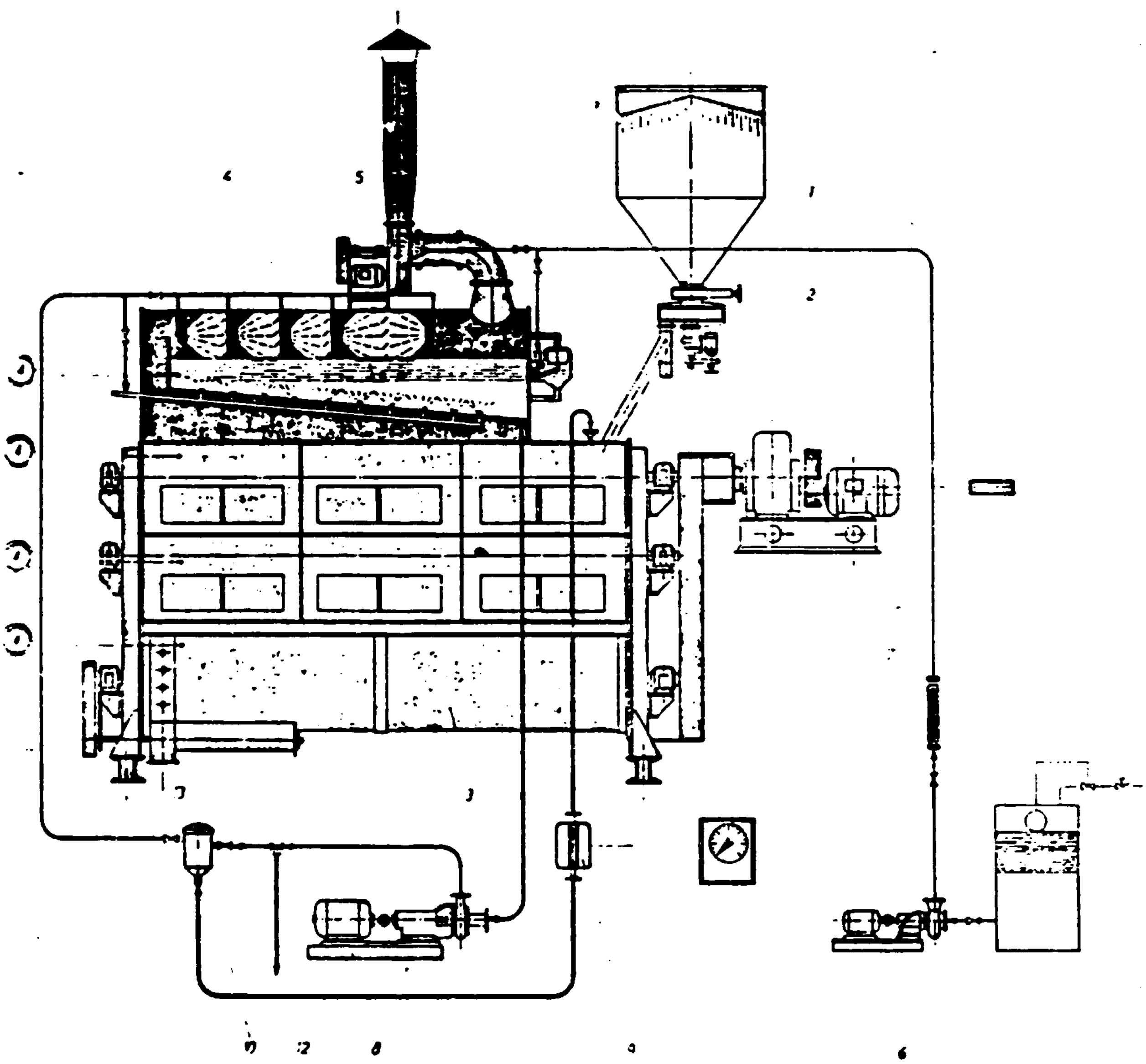
1 3-chamber lime hydrator, consisting of
- pre-hydrator, ø 500 mm x 6,3 m L
- main hydrator, ø 630 mm x 6,3 m L
- after hydrator, ø 800 mm x 6,3 m L

1 electric motor, 18,5 kW, 1500 rpm

1 hot water producer - wet dust filter, 50/630 mm

<u>Cost U$S 125.000</u>

	SUBJECT: LIME HYDRATOR 3-stage type KLD	Figure no. 1 SHEET NO. 1 OF 1 JOB NO. UNIDO 79/005 DATE Jan. 1980



1. Feed hopper for quicklime
2. Feeder
3. 3-chamber hydrator
4. Dust remover
5. Ventilator
6. Freshwater pump
7. Measuring device
8. Circulation pump
9. Measuring device
10. Refuse separator
11. Temperature indicator
12. Emergency outlet
13. Outlet for hydrated lime

SUBJECT: LIME HYDRATOR

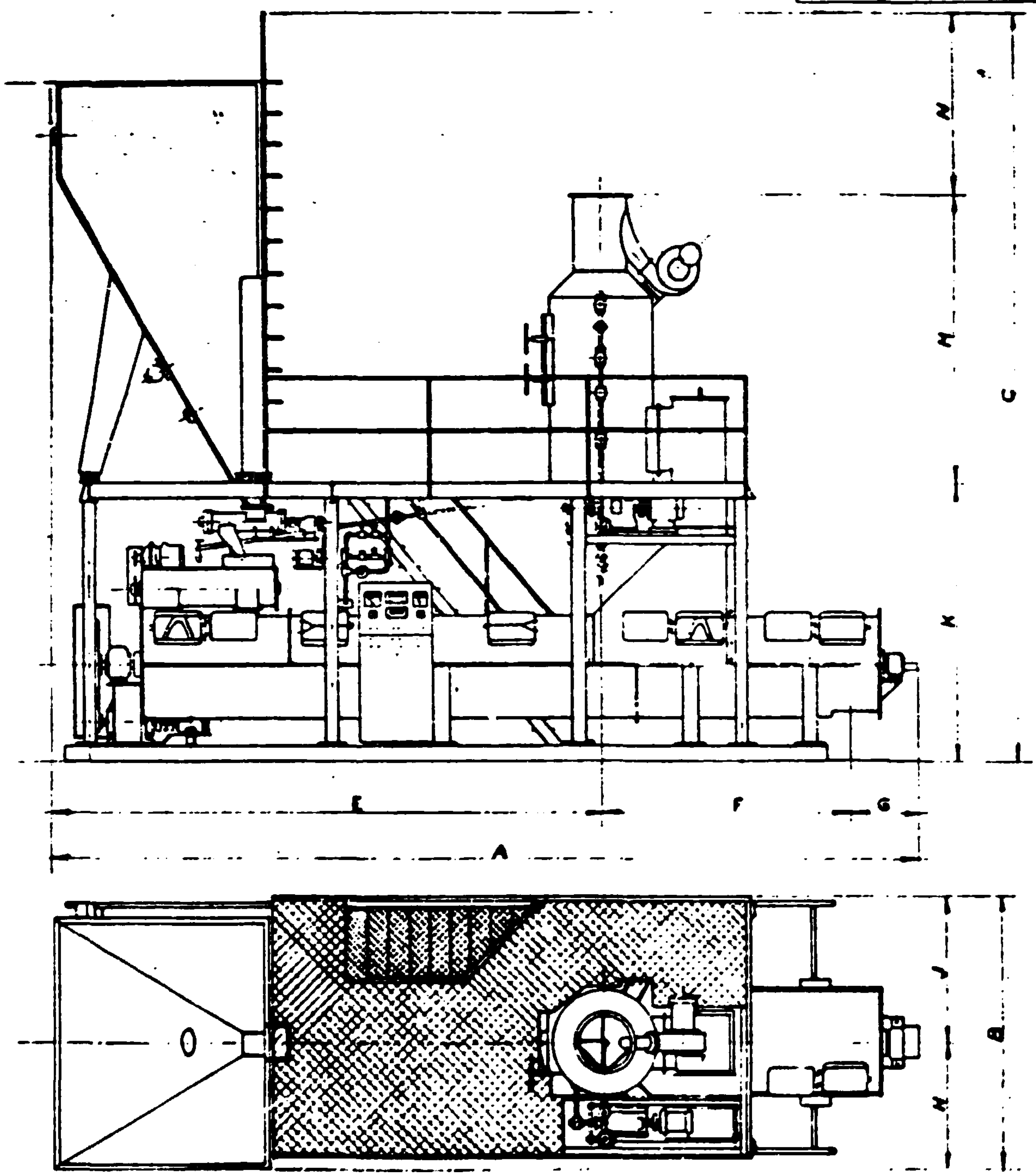
type Peach-Rover

Figure no. 2

SHEET NO. 1 OF 1

JOB NO. UNIDO 79/005

DATE Jan. 1980

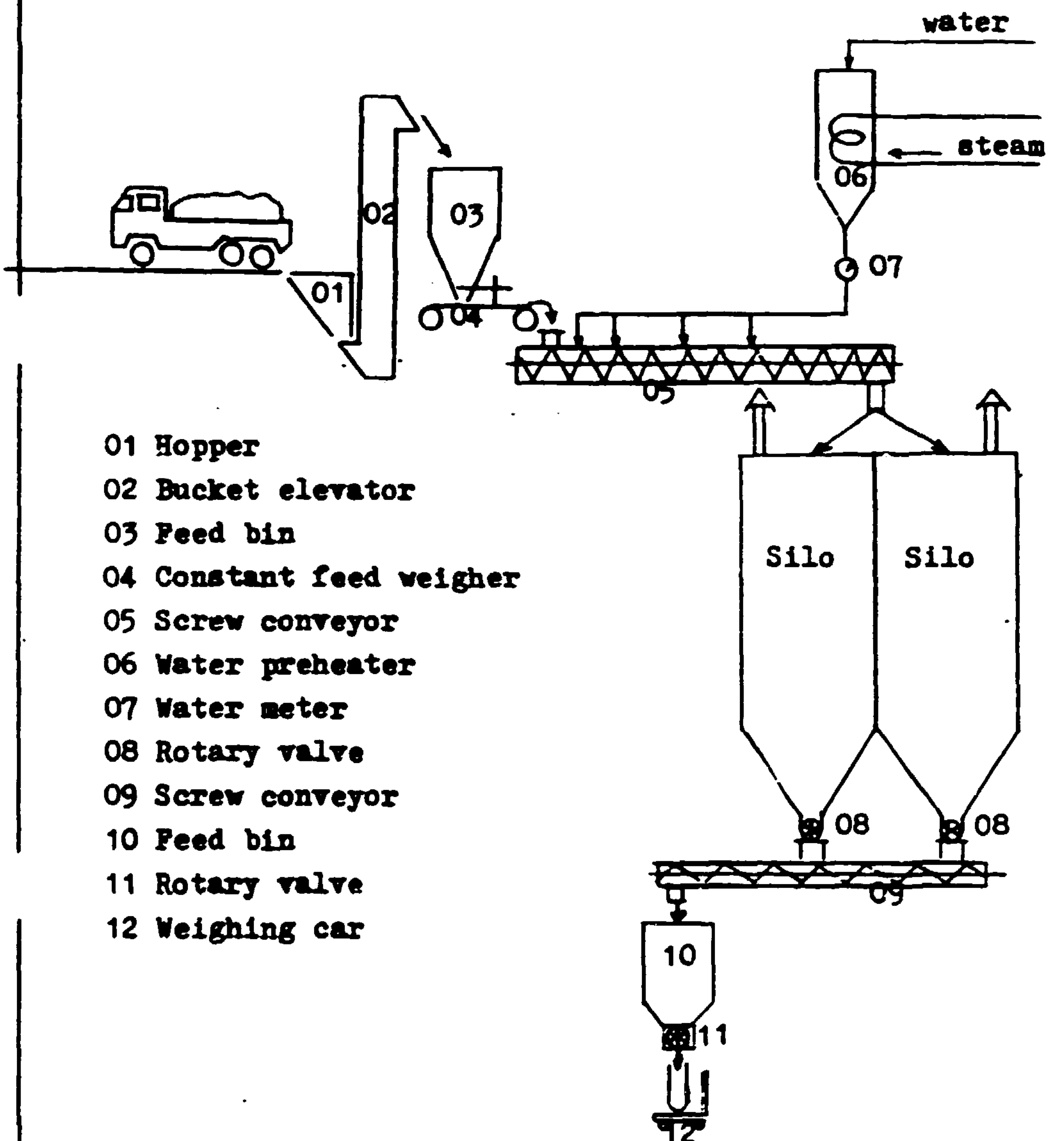


Capacity: 3 - 3,5 t/h. General dimensions

A	B	C	D	E	F	G	H	J	K	L	M
5300	2400	7000	6000	3000	1800	500	1200	1200	2600	2700	1700

Weight: 6380 kg

SUBJECT:	LIME HYDRATOR type TIAVEH	Figure no. 3
		SHEET NO 1 OF 1
		JOB NO. UNIDO 79/005
		DATE Jan. 1980



01 Hopper
02 Bucket elevator
03 Feed bin
04 Constant feed weigher
05 Screw conveyor
06 Water preheater
07 Water meter
08 Rotary valve
09 Screw conveyor
10 Feed bin
11 Rotary valve
12 Weighing car

b) Single stage hydrator, type Peach-Rover, capacity 3,5 t/h Fig. No. 2.

1 slaking cylinder, ø 650 mm x 8,0 m L

1 electric motor, 13 kW, 1500 rpm

1 lime scrubber and hot water producer, ø 800 mm x 2,7 m H

1 instrument panel

Cost U$S 65.000

Both the 3-stage and the single stage hydrator will of course need raw material silos, bucket elevators, screw conveyors etc. to form a complete unit.

c) Lime hydrator, type TIAVEH, capacity 3,5 t/h, Fig. No. 3.

1 lime hopper, 3,0 m x 1,0 m x 2,0 m

1 bucket elevator, 150 mm, 20 m/min, 15 m H, motor 1,5 kW

1 feed bin, 3,0 m x 5 m H

1 constant feed weigher, 400 mm, motor 1,5 kW

1 screw conveyor, ø 450 mm x 9,0 m L, motor 5,5 kW

1 water preheater, ø 400 mm x 3,0 mH

1 water meter

2 rotary valves, ø 150 mm x 150 mm W, motor 1,5 kW

1 screw conveyor, ø 200 mm x 5,0 m L, motor 1,0 kW

1 feed bin

1 rotary valve, ø 150 mm x 150 mm W, motor 1,5 kW

1 weighing car, capacity 50 kg

Cost (excluding reactor silos) u$S 35.000

As can be seen from the above the last alternative represents an economical type of lime hydrator but once again it is emphasized that a strict control must be maintained in regard to the feeding of water and quicklime. Naturally it is also important that the quicklime is of a proper and constant quality.

6.1.3. While stages I and II in the pozzolime process are preliminary stages for the preparation of the raw materials, stage III is the final process in which the dry raw materials are interground to the specified fineness and finally bagged ready for use.

The intergrinding can suitably be done in a ball mill or in a roller mill (see Fig. No. 4 and 5). The ball mill is perhaps more common whilst the roller mill presents certain advantages.

As a first alternative the complete process including all three stages is shown in the flowsheet, fig. No. 6. It shows receiving of the pozzolana, its crushing and drying in a rotary drier whilst the exhaust gases are cleaned in a battery of cyclones. The crushed and dried pozzolana then is fed into a ball mill together with the dry lime hydrate. The air evacuated from the mill is passed through a bag filter whilst the milled end product is taken to a product hopper and then bagged.

A second alternative would be to use an air-swept while drying grinding plant based on an MPS roller mill, combined with a whizzer type classifier and a hot gas generator. This has the advantage that it will be possible to directly dry the wet feed material during the grinding process by passing hot air

SUBJECT: GRINDING MILLS	Fig. no. 4 & 5
	SHEET NO. 1 OF 1
	JOB NO. UNIDO 79/005
	DATE January 1980

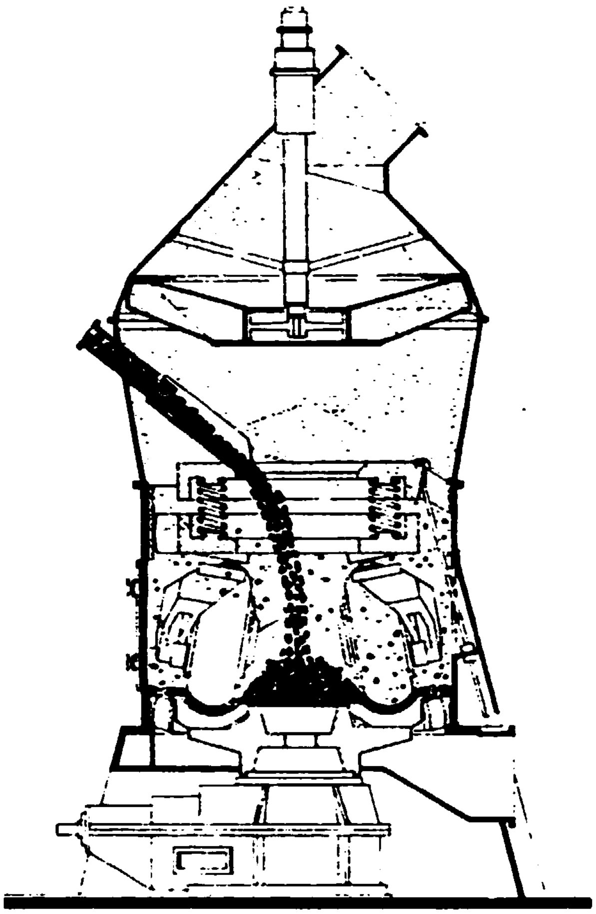


Fig. no. 4

Roller mill:

Three big grinding rollers arranged at fixed points above a rotating grinding bowl. Drying according to air sweep principle. Pulverized material transported to air classifier.

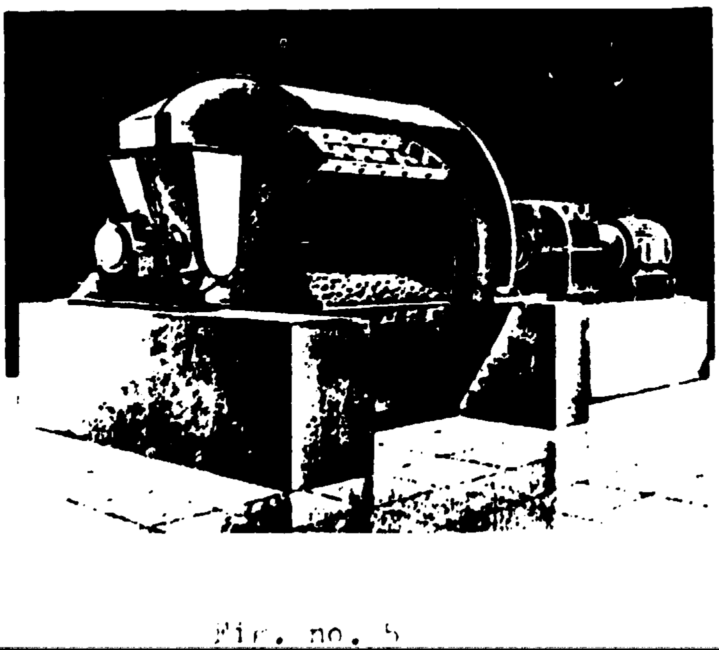


Fig. no. 5

Ball mill:

Cylindrical shell provided with lifters and with a charge of steel balls. Rotating speed 80% of critical.

into the mill. Thereby it is not necessary to envisage a separate drying plant. The most important advantage of this type of mill is however the up to 30% lower specific power consumption. This process is demonstrated in the flowsheet fig. No. 7. The two raw materials, ground in the mill to a fineness 3 - 5% coarser than 75 micron, will be seized by the air-stream and removed from the mill and be separated from the air in a cyclone and in an air pressure filter. For the bagging of the pozzolime into open bags of 35 kg each, two packing machines are necessary.

Which alternative to choose will depend upon the size of the plant. The ball mill alternative can be used for capacities down to 40 t/d whilst the roller mill alternative must have at least a capacity of 100 t/d, preferably 200 t/d. Even at 100 t/d the second alternative is higher in investment cost but power consumption is less. For the financial analysis the ball mill alternative has been chosen.

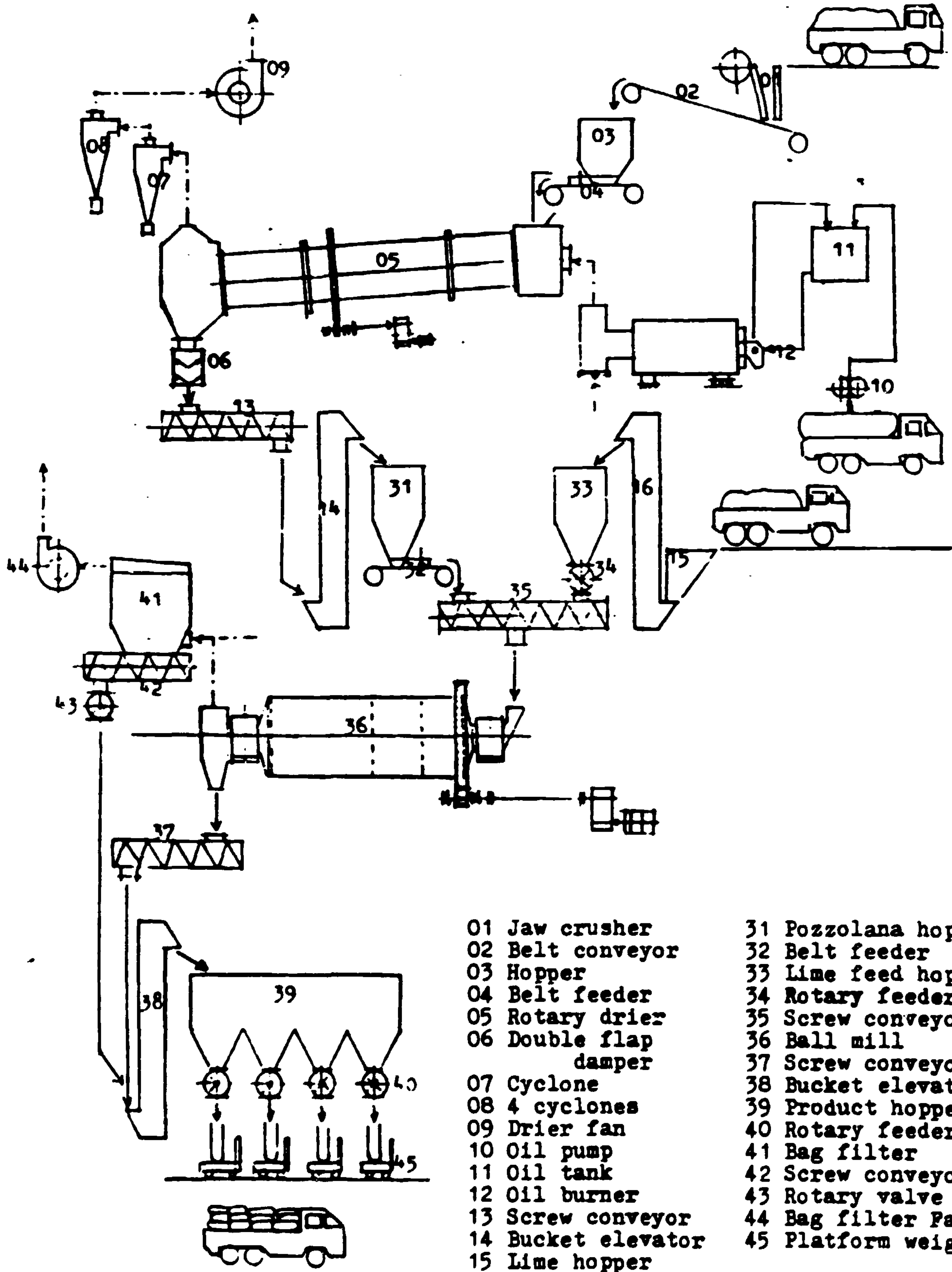
<u>Specification for a 40 t/d pozzolime plant</u>

(see flowsheet fig. No. 6)

Capacity	40 t/d
Raw materials, dry	
- pozzolana, 67%	27 t/d
- lime hydrate, 33%	13 t/d
Operation hours	
- materials receiving	8 h/d
- drying	24 h/d
- grinding	20 h/d
- packing	8 h/d

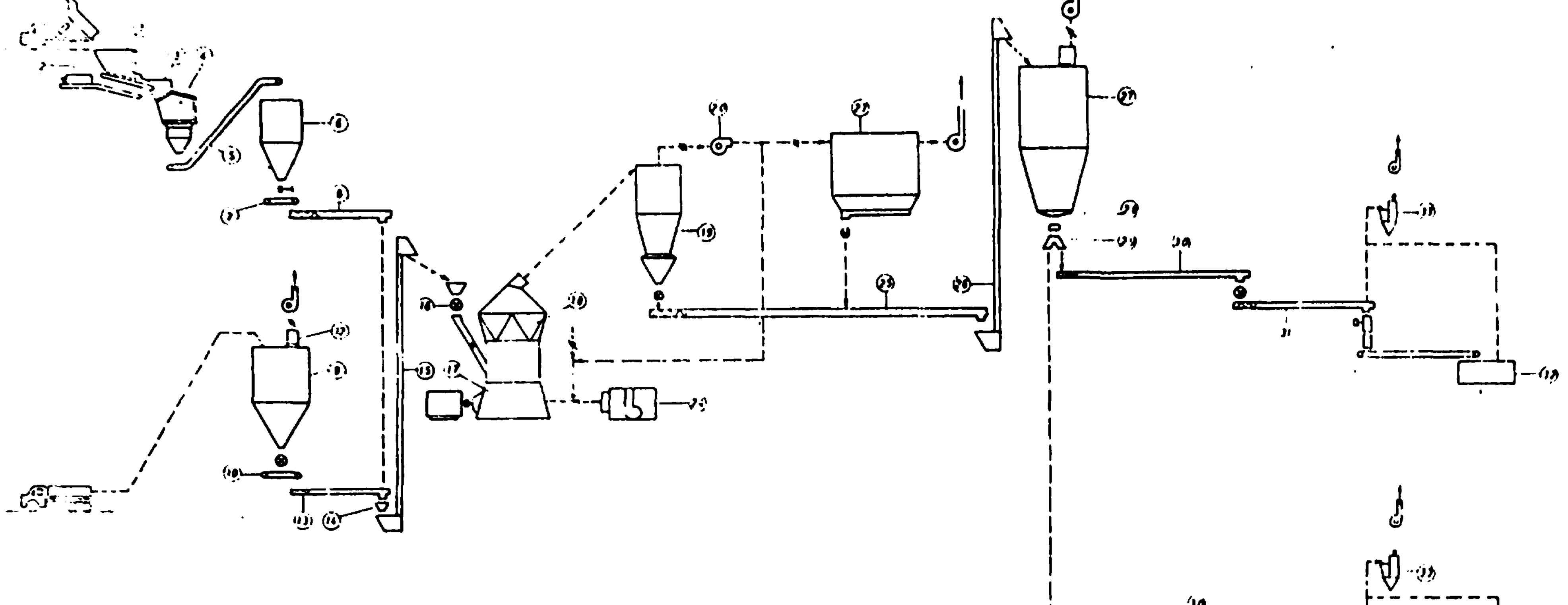
Figure No. 6

Flowsheet Pozzolime Manufacture
Process Fujino - Grane



01 Jaw crusher
02 Belt conveyor
03 Hopper
04 Belt feeder
05 Rotary drier
06 Double flap damper
07 Cyclone
08 4 cyclones
09 Drier fan
10 Oil pump
11 Oil tank
12 Oil burner
13 Screw conveyor
14 Bucket elevator
15 Lime hopper
16 Bucket elevator
31 Pozzolana hopper
32 Belt feeder
33 Lime feed hopper
34 Rotary feeder
35 Screw conveyor
36 Ball mill
37 Screw conveyor
38 Bucket elevator
39 Product hopper
40 Rotary feeder
41 Bag filter
42 Screw conveyor
43 Rotary valve
44 Bag filter Fan
45 Platform weigher

Fig. no. 7



1 Feeding bin
2 Reciprocating push feeder
3 Inlet head
4 Impeller mill
5 Steeply inclined belt conveyor
6 Silo for puzzolan
7 Fully automatic proportioning belt scale
8 Trough-type chain conveyor
9 Silo for lime hydrate
10 Fully automatic proportioning belt scale
11 Control system for the material mixture
12 [illegible] filter
13 Trough type screw conveyor FST 20
14 Inlet head

16 Rotary air lock DSZ 40
17 Roller mill MPS 100 A
18 Air-swept whizzer type classifier, type SLF 150
19 Cyclone collector, type AZC 180
20 Mill fan
21 Measuring and regulating equipment for the automatic operation
22 Set of pipes
23 Dust collection for the grinding plant
24 Hot gas generator
25 Trough type screw conveyor FST 20
26 Chain bucket elevator, type FBK
27 Silo
28 Discharge equipment
29 Compensator [illegible]

30 Bagging unit
31 [illegible]

FLOW SHEET FOR THE MANUFACTURE OF LIME-PUZZOLANA CEMENT
PROCESS GRANE-C.[illegible]K

Fig. No. 7

Machinery:

01 Jaw crusher, 250 x 400 mm, 300 rpm, motor 11 kW

02 Belt conveyor, 400 mm x 36 m, 40 m/min, motor 1 kW

03 Hopper, ø 3,5 m x 6,5 m H

04 Belt feeder, 400 mm, 1,9 m/min, motor 1 kW

05 Rotary drier, ø 1,4 x 13 m L, incl. 3^{o}, 5 rpm, motor 11 kW

06 Double flap damper, 150 mm, 15 rpm, motor 1 kW

07 Cyclone, ø 750 mm x 2250 mm H

08 4 cyclones, ø 320 mm x 960 mm H

09 Drier fan, 400 mm aq., 1450 rpm, motor 5,5 kW

10 Oil pump, 20 kg/h, pressure 3 kg/cm^2, motor 3,7 kW

11 Oil tank, ø 1,5 m x 2,4 m H

12 Oil burner, rotary type, max. 50 l/h, furnace ø 1,0 m x 2,0 m L

13 Screw conveyor, ø 200 mm U-type, 30 rpm, distance 5,0 m L

14 Bucket elevator, 150 mm W, 20 m/min, center distance 15 m H, motor 1,5 kW

15 Lime receiving hopper, 3 m x 1 m x 1,8 m

16 Bucket elevator, 150 mm, center distance 15 m H, 25 m/min, 1,5 kW

31 Pozzolana feed hopper, ø 3,5 m x 5,5 m H

32 Belt feeder, 400 mm W, 2 m/min, motor 1 kH

33 Lime feed hopper, ø 3,5 m x 5,5 m H

34 Rotary feeder, ø 150 mm x 300 mm H, motor 0,4 kW

35 Screw conveyor, ø 200 mm valve type, 30 rpm, 5 m L, motor 1,0 kW

36 Ball mill, ø 1,5 m x 5,5 m L, 25 rpm, 11,5 t balls, motor 120 kW

37 Screw conveyor, ø 2[illegible] mm valve type, 30 rpm, 5 mL, motor 1,0 kW

38 Bucket elevator, 150 mm x 15 m H, 25 m/min, motor 1,5 kW

39 Product hopper, ø 4 m x 9 m H

40 Rotary feeder, ø 150 mm x 300 mm H, 20 rpm, motor 0,4 kW

41 Bag filter, collecting area 60 m^2, pressure loss 150 mm aq., 1,5 kW

42 Screw conveyor, ø 100 mm valve type, 5 m L, 20 rpm. motor 0,4 kW

43 Rotary valve, ø 100 mm valve type, 5 m L, 20 rpm. motor 0,4 kW

44 Bag filter fan, 300 mm aq. at 60°C, 1450 rpm, motor 7,5 kW

45 Platform weigher, capacity 50 kg

Cost: U$S 403.000

100 t/d and 200 t/d pozzolime plants

The larger capacity plants will use the same layout as the 40 t/d plant but with some changes:

- the cyclones after the rotary drier are exchanged for a bag filter.
- the open circuit used in the milling line is exchanged for a closed circuit arrangement

Otherwise the layout is similar but the individual pieces of machinery obviously are larger sized to be able to render the higher capacities.

Cost price:

100 t/d plant, equipment and machinery	U$S 856.000
200 t/d plant, equipment and machinery	U$S 1.165.000

7. TENTATIVE FINANCIAL ANALYSIS

Using the foregoing information, cost estimates for three different sizes of pozzolime plants has been prepared and also the operating results have been worked out. As usual the profit increases with the output. The output from the smallest unit, showing the lowest profit, could possibly be increased to 50 t/d which would have a favourable influence on the profit. From the size of the investment from that small plant, U$S 800.000, it is clearly seen that this is not a village-type industry.

Cost Estimate for Pozzolime Plants

Capacity, t/d	40	100	200
Receiving and drying line U$S	139.000	296.000	401.000
Grinding line	232.000	396.000	562.000
Packing line	32.000	164.000	202.000
Total mechanical equipment	403.000	856.000	1.165.000
Electrical equipment	48.000	133.000	174.000
Various material	20.000	50.000	
Spare parts	20.000	43.000	54.000
	491.000	1.112.000	1.393.000
Insurance (1%)	4.910	11.120	13.930
Freight (5%)	24.555	55.610	69.645
Handling charges, 5% on CIF	26.032	58.947	73.825
Local transportation (2%)	9.823	22.243	27.860
Erection + installation	22.500	63.500	80.000
Total cost U$S	578.820	1.323.420	1.658.260

A detailed cost study for the installation and running of a 40 t/d pozzolime plant is found in the following paragraph followed by a comparative study of a 40, 100 and 200 t/d plant.

Cost Study
of 40 t/d pozzolime plant

A. Fixed costs

1 Factory

1.1 Buildings		
200 m^2	à U$S 100	U$S 26.000
320 m^2	à 65	20.800
180 m^2	à 50	9.000
1.2 Storage, 75 m^2	à 50	3.750
1.3 Office + lab. 65 m	à 120	7.800
1.4 Mech. + El. work shop	à 120	4.200
1.5 Land, 5000 m^2	à 6,50	32.500
1.6 Contingencies, 10%		9.750
		U$S 107.800

2 Mining Site

2.1 Land, 5 hectars à U$S 8.000	U$S 40.000
2.2 Buildings, 125 m^2 à U$S 50	6.250
2.3 Equipment and tools	10.000
	U$S 56.250
Total Cost	U$S 164.050

Annual depreciation of factory and mining site over 20 years, U$S 8.200.

3. Machinery and equipment

3.1 Design, engineering and delivery of machinery and mechanical equipment,	U$S 403.000	
3.2 Electrical equipment, 12%	48.300	
3.3 Various, 5%	21.150	U$S 472.450
3.4 Spare parts, 4%		18.900
3.5 Insurance, 1%		4.700
3.6 Freight, 5%		23.600
3.7 Import handling charges, 5% on CIF price		26.000
3.8 Local transportation, 2%		11.000
3.9 Erection + installation		22.000
		U$S 578.650

Annual depreciation over 10 years = U$S 57.800

4 Administration and Sales

1 Sales Manager	U$S 650
1 Accountant	560
1 Secretary	200
2 Clerks á U$S 120	240
	U$S 1.650/mo

Annual cost of administration and sales (13 mo) U$S 21.450

5. Senior Technical Staff

1 Plant Superintendent	U$S	650
1 Production chemist		400
3 Foremen á U$S 120		360
	U$S	1.410/mo

Annual cost of senior technical staff (13 mo) U$S 18.330

B. Variable Costs

6. Labour:

- Pozzolana receiving	2 x 1 shift	= 2
- Drier	2 x 3	= 6
- Mill	2 x 3	= 6
- Lime receiving	2 x 1	= 2
- Packing	8 x 1	= 8
- Mechanics	1+1 x 3	= 4
- Electricians	1+1 x 3	= 4
- Laboratory		= 1
- Miscellaneous		= 5
		38 persons

		Cost per day
Production:	24 á U$S 2.40	U$S 57.60
Maintenance:	9 á 2.80	25.20
Laboratory:	1 á 2.40	2.40
		U$S 85.20

Annual cost of labour (325 days) = U$S 27.690

7. Raw Materials and Utilities

	Per ton
Pozzolana, 0,838 t @ U$S 3.00	U$S 2.51
Lime, 0,337 t @ $ 17.40	5.86
Fuel Oil, 36 lit/t dry pozzolana @ $ 0.05	1.80
Grinding media, 250 g/t $ 1.25	0.31
Lub. oil, 0,2 lit/t @ $ 0.65	0.13
Grease, 0,1 kg/t @ $ 1.00	0.10
Electricity, 46,9 kwh/t @ $ 0.04	1.88
Bags, 33,3 pcs @ $ 0.17	5.66
Miscellaneous material, 10%	1.83
	U$S 20.08

At an annual production of 12.000 t total cost is U$S 240.960

Total cost

The total Fixed Costs per annum are:

1. Factory and mining site	U$S 8.200
2. Machinery and equipment	57.800
3. Administration and sales	21.450
4. Senior technical staff	18.330
	U$S 105.780

The total variable costs per annum are:

6. Labour	U$S 27.690
7. Raw materials and utilities	240.960
	U$S 268.650

Total fixed and variable costs are U$S 374.430

At a production of 12.000 tons of pozzolime per year the cost per ton is U$S 31.20 = U$S 1.04/bag of 33,3 kgs.

In the following a comparative cost study is made for a 40, 100 and 200 t/d pozzolime plant.

The machinery costs are those estimated earlier with the addition for insurance, freight, import handling charges and local transportation cost.

Erection and installation are included in the prices.

For the two larger plants the following price increases have been made:

	100 t/d	200 t/d
- factory	+ 20%	+ 30%
- mining site	same	+ 5 har
- machinery	as calculated	
- admin. + sales	+ 25%	+ 50%
- techn. staff	+ 25%	+ 50%
- labour	+ 40%	+ 50% on 100 t/d
- raw materials	according to capacity.	

Comparative Cost Study (in U$S)

for 40, 100 and 200 t/d pozzolime plants

	40 t/d	100 t/d	200 t/d
Investment:			
- factory	107.800	129.360	140.140
- mining site	56.250	56.250	96.250
- machinery	578.650	1.323.420	1.658.260
- working capital (4 mo of raw mtrl + utilities)	80.000	200.000	400.000
	822.700	1.709.030	2.294.650
Operating costs:	12.000 t/yr	30.000 t/yr	60.000 t/yr
A. Fixed costs			
1. Factory	5.390	6.470	7.010
2. Mining site	2.810	2.810	4.810
3. Machinery	57.800	132.340	165.830
4. Admin. + sales	21.450	26.810	32.180
5. Techn. staff	18.330	22.910	27.500
	105.780	191.340	237.330
B. Variable costs			
6. Labour	27.690	38.770	58.155
7. Raw mtrl+util.	240.960	602.400	1.204.800
	268.650	641.170	1.262.955
Total fixed and variable costs per annum	374.430	832.510	1.500.285
Cost per ton	31,20	27,75	25,00

Illustrative Projection of Financial Operating Results

(US$ x 1000)

	40 t/d	100 t/d	200 t/d
Sales, at $ 41,50/t	498	1245	2490
Costs	375	832	1500
Gross Profit before interest and tax [1]	123	413	990
Allowance for interest	82	171	229
Net Profit	41	242	761
Net profit as % of sales	8	19	31
as % of investment	5	14	33

1) Assumes 10% interest on investment

Assumes no tax payable first 5 years

8. THE USE OF POZZOLIME

8.1 Mortar, plaster, concrete

Pozzolime can advantageously replace portland cement both in mortar and plaster and even in concrete for foundations and flooring when no particularly high structural strength is required. Tests made with a lime-trass binder (1:2) has shown good bond strength and excellent plastering properties and in concrete a compressive strength well above the required was obtained.

The cost of a standard mortar 1:3 by weight of pozzolime and sand compared to cement and sand is shown below:

	Indonesia	Venezuela	Argentina
Pozzolime	US$ 41,50/t	US$ 46,50/t	US$ 65/t
Portland cement	56/t	69/t	125/t
Sand	6/t	6,30/t	7/t
Portland cement mortar	18,50/t	21,98/t	36,50/t
Pozzolime mortar	14,88/t	16,85/t	19,00/t
Reduction in cost	24,3%	30,4%	79%

As can be seen from this table considerable savings can be made substituting portland cement by pozzolime.

8.2 Stabilized soil bricks

Pozzolime is very well suited for the production of stabilized soil bricks. Such bricks consisting of a mixture of pozzolime and soil 1:10 up to 1:15, can be either completely hand-made or produced in a simple, manually operated press. A vastly better product is obtained if a motordriven press is used whereby compressive strength up to 60 kg/cm^2 can be obtained, sufficient even for multistorey buildings. Important is that the soil has the right properties, i.e. it should be a cohesive or semi-cohesive soil. To destroy the capillary rise in the brick and the soaking-in of surface water the addition of a capillary breaking agent (e.g. asfalt emulsion) is recommended.

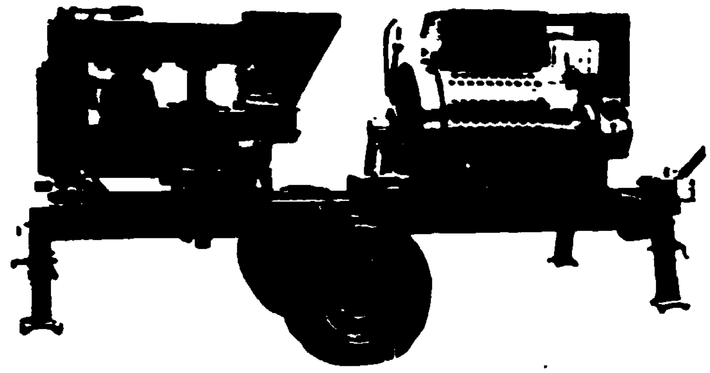
As transport costs in developing countries generally are high, small mobile units, which can produce the necessary amount of bricks on the spot from local soil, is very advantageous. One such mobile plant (see fig. No. 8) provided with its own source of power, a 11 HP diesel engine, with a 140 litre paddle mixer and a 12 ton hydraulic press, as shown in fig. No. 8, is mounted on a 2-wheel chassis, can easily be moved from one building site to another, from one village to another. It can produce 200 - 300 bricks (25 x 12 x 7,5 cm) per hour or say up to 3000 bricks per 10 hour day. This plant is attended by 4 men:

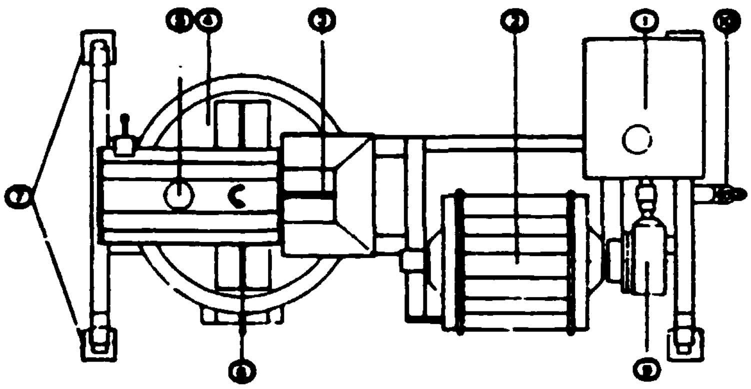
No. 1: fill mixer with 100 liters of soil, add necessary water plus capillary-breaking agent

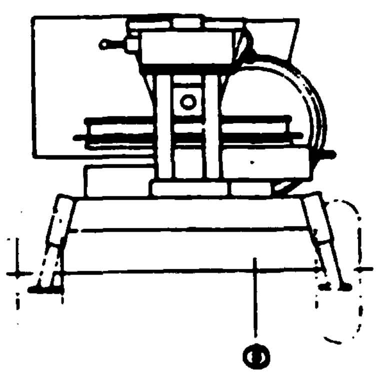
No. 2: empty mixer and fill feeding bin of press

No. 3: operate the press moving the table in position, smooth the filled moulds and activate the press

SUBJECT:	MOBILE SOIL BRICK PLANT Type Consolid CLU-2000	Figure no. 8
		SHEET NO. 1 OF 1
		JOB NO. UNIDO 70/005
		DATE January 1980







1. Diesel engine
2. Paddle mixer
3. Hopper
4. Rotary table
5. Hydraulic press
6. Hydraulic extrusion
7. Telescope legs
8. 2 tire wheels
9. Gear
10. Shaft bar

Mixer:	140 litre paddle mixer
Press:	Hydraulically operated, total pressure 12 ton
Power:	11 HP diesel engine, air-cooled, fuel 2 lit/h
Transport:	2-wheel axle with 7.00 x 14 8 PR tires
Installation:	Firm positioning on 4 telescope legs
Total weight:	Approx. 1550 kg
Production:	200 - 300 bricks (25 x12 x 7,5 cm) per hour

No. 4: take away the pressed bricks and put them on shelves in the drying barn.

To place the pressed bricks in the drying barn one or two more helpers may be needed.

Cost estimate:

Raw materials		
- pozzolime, 1 part, 1 ton @ U$S 41,50	=	U$S 41,50
- soil, dry, 11 parts, 11 tons @ $ 2	=	22,00
- chemicals	=	8,00
		71,50
Labour, 6 men @ $ 3	=	18,00
Diesel oil, 20 lits. @ $ 0,10	=	2,00
		U$S 91,50

= U$S 30,30 per 1000 bricks (direct costs)

9. FOLLOW-UP ACTION

It is recommended that the following steps be taken if the establishment of a Pozzolime plant is contemplated.

(1) Investigate the availability of suitable raw materials.

(2) Conduct a market survey to determine possible demand for pozzolime as well as a realistic sales price.

(3) Decide capacity of plant

(4) Examine possible Government approval and support.

(5) Explore the possibilities to finance the project.

(6) If and when the above points have been satisfactorily investigated proceed with a detailed technical design and call for tenders from suppliers.

Possibly UNIDO can assist or recommend assistance for the evaluation of proposals received and advice on the implementation of the project.

Among possible equipment suppliers, the following can be mentioned:

- Gebrüder Pfeiffer A.G., P.O. Box 3080, D-6750 Kaiserslautern, West Germany.
- Minyu Machinery Corp. Ltd., P.O. Box 264, Taipei, Taiwan, R.O.C.
- Onoda Engineering and Consulting Co. Ltd., 1-1-7 Toyuso, Koto-ku, Tokyo, Japan.
- Charles Bergling & Co. A.B., Odinsgatan 22A, Göteborg, Sweden.

10. BIBLIOGRAPHY

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