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FINAL REPORT

Project Number DP/IND/84/004

Project Techno-Economic Study for Industrial Utilization of Red Mud Waste from Bauxite Processing in India

UNIDO Contract No. 85/3

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Chapter One

Executive Summary

Executive Summary

Following the recommendation from UNEP, the Indian Government requested assistance from UNIDO in establishing the technical and commercial feasibility of adapting a proprietary method of red mud waste utilization for the production of building materials, elaborated by Mr. Ferenc Puskás.

Based on a field trip, laboratory tests and a subsequent pilot-scale production demonstration using red mud and various mineral additives, all of Indian origin, the following findings have been made and are reported in greater detail in this Report.

1) Red mud from the current alumina production of the local factory (Korba) is the waste of production, can be combined in formulas with additives to yield products with acceptable to excellent quality parameters. Possible products include brick and glazed floor- and wall-tiles by single-firing technique. Red mud content of such products range up to 45 p.c. Present production and discharge practices of red mud require only a little change in the production.

2) Considering the size of the Indian building materials market the amount of red mud waste is not limited for building industrial purposes due to the fact that the demand highly surpasses the manufacturing possibilities.

3) As energy accounts for approx. lo p.c. of total production cost of individual types of building materials, the

cost of energy is largerly influenced what kind of fuel is used.

4/ The specific energy demand of the universal floor and wall tiles is reduced by 4o p.c. in comparison tothe energy requirement of the traditional technique. The suggested method of singleófiring has been a result of great importance all over the world.

5/ Semi industrial scale production test proves the possibility to produce excellent quality ceramic tiles from red mud and mineral additives. It is proposed that a plant be beuilt to produce 2.ooo.ooo. sq.m. floor and wall tiles per year. Capacity can be increased according to the requirement. One part of the equipment of the plant is of local manufacture. The value of the import equipment does not surpass 4,5 mill USD. The settlement of the pant enables the further development of the industry and the use of the products for the local communal buildings. In addition a lot of cities are within some hunderd of km radius, thus the transport problems can be reduced to a minimum. The red mud based product produced in Korba permits a flexible marketing strategy because the raw material is available practically free.
It is recommended that the Government of India encourage a red mud waste based production. The method recommended makes it possible that after the expansion of capacity a greater quantity of the wastes can also be processed. From the economic calculation it can be seen that the rate of return of capital has been 2 years, net cash flow 43.355.6oo Rps per year. The plant calculation of unglazed tile production is also calculated as an alternative solution.

The total capital requirement of the glazed tile factory for the production of 2 mill. sq.m. has been 191.14o.ooo Rps.

6/ On the basis of the results of laboratory tests and pilot scale demonstration the erection of a plant producing calcium bond walling bricks with a dimension of 22o x 11o x 55 mm by cold technology with an annual capacity of 1o mill pcs can be suggested. Investment cost of such a plant has been 1o.o9o.ooo Rps. The energy saving of this plant in comparison tothe traditional brick production has been 3o p.c. Payback period of the factory has been 3,96 years. Net cash flow: 1.o18.65o Rps/y. The technology utilizes 1o.ooo t red mud and 8.ooo t fly ash.

Chapter Two

Project Background and Project History

Project Background and History

2.1. Project Background

The method to produce aluminium by electrolyses was invented by the French Héroult and the American Hall in 1886. The technology of alumina production was patented by the Austrian Bayer in 1892.

Over the part loo years the production and industrial use of aluminium have risen from an annual quantity of a few hundred tons to 15 million tons on a global scale. To produce unit quantity of aluminium requires twice that amount of alumina. The Bayer process yields 1.2-1.4 tons of red mud per alumina tons, i.e. not less than 4o million tons of red mud is produced in the alumina factories of the world every single year.

While production figures ran low, the disposal of red mud in mud ponds was no great difficulty. Specialists were confident that by the time red mud disposal was to become a headache for them feasible methods to make the best use of red mud would have been found.

Initial efforts to put red mud to industrial use lay in the direction of smelting, as was indicated by its high ferro-oxide content, which may run up to 4o-6o p.c.

Efforts at smelting resulted in various patented processes but no industrially and economically feasible method has been found to date. Repeated economic analyses have proved that the pre-produce of iron ire subsitute is non-competitive not so much because of its specific technological parameters as the high capital investment involved.

Up to quite recent times all efforts to find uses for red mud in large quantities have failed, and so this by-product keeps on accumulating year after year.

As is well known to specialists, the Bayer process, although the most successful method of alumina production known to us, has certain disadvantages. Furthermore, its drawback stems from one of its fundamental technological phases that originally put it at an advantage over all other efforts in this direction. Notably, that ground bauxite is transformed at 1oo-28o °C, at 6-8o kp/cm^2, with the addition of concentrated caustic soda into water-soluble sodium aluminate and insoluble Si, Fe, Ti, etc. compounds. The insoluble solid parts of bauxite processed with caustic soda are removed by filtering from the sodium aluminate solution, and this removed material is in fact what we call red mud. If the solid residue did not contain free caustic soda of an aggressive character as well as about 1o p.c. sodium oxide equivalent to bound sodium compound, then red mud would not at all be a hazard to the environment. However, the high amount of sodium it does contain makes red mud an ever-growing menace to fields, woods, meadows and river life.

It would be easy to find a way out if we could process bauxite with an alkali whose residue in red mud were no danger to the living world. Also, bauxite exploitation today can be accomplished with the help of acids and acidics coupled with an appropriate closed-system technology and alkali neutralization of solid mud remainders. However, it would be too early to regard these possibilities as as large scale, industrial solution to the problems outlined. However, it is rather likely that one of these methods - now at an experimental stage - will grow into the basic technology of alumina production and replace the Bayer process by the turn of the century.

Of course the quantity of red mud and the worries it gives us will continue to grow until that time. There is a certain limit to increasing the surface area of artificial mud ponds, which cost money to build, may tie up valuable farmland and which may be positively harmful over a much larger area than the pont itself, if a leakage of sodium solution occurs due to insufficient water insulation. If the sodium solution reaches ground water, rivers and lakes, it will become a hazard not only to plants but animals and humans as well. Some alumina factories try dumping the mud into the sea, a method that has provoked angry public response and is, therefore, radically discouraged by some governments. So the question naturally arises whether there is any good solution to red mud disposal.

A noteworthy technique of storing red mud has been developed by the German Gebrider Guillini Co. After the sodium aluminate solution is separated from red mud sludge, red mud is filtered in a drum filter, washed and chemically processed in a reactor called mixer, then processed with a fluxmaterial and finnally, when the sludge has lost much of its water content, it is carried to the storing area by means of pumps.

Due to chemical processing, natural evaporation and the natural water balance of the storing area, the processed red mud soon looses its surplus water content and hardens so much that it can even carry heavy machinery. These kinds of red mud storing areas need no special water insulation because the water soluble sodium salt content is below o.5 p.c., so the danger to the environment is at a minimum. Red mud hardened by the Guillini process can be stored in waste-tips 25 metres high, therefore, demand for ground area is reduced to one-fifth of that of traditional mud ponds.

As mentioned before, red mud consists of finely ground silicates, iron-hydroxide and other practically water-insoluble compounds as well as of residual caustic soda and other soluble salts. Recent decades have seen attempts to look at red mud as a finely granulated homogeneous additive material for the ceramic industry rather than a raw material for metallurgy.

The initiative was again taken by the German Guillini Co., and brick production has in recent years been successfully conducted in one factory in South Germany by the method they have developed and patented. The technology is as follows. Red mud is mixed with a hygroscopic material and a large quantity of clay, moulded into bricks by the traditional process, dried and fired at about 9oo°C. The mixture has a red mud content of some 4o p.c.

The Guillini bricks excelled clay bricks in quality, with special regard to strength, the former product was found 2 to 4 times stronger than the latter. It was established, however, that firing gets increasingly difficult with a rise in red mud content, and that the method was only successful in the case of red muds of low or medium ferro-oxide content.

More importantly, the economics of such a production proved to be insufficient to keep balance with the accompanying problems. For one thing, South of Germany is rich in cheap clay of excellent quality and most brick yards own their clay mine. There was little incentive for the brickmaker to replace his clay with red mud, especially as clay could not be replaced totally. Since the cost of mining does not scale well with decreasing quantity, the unit cost of clay to the brick company went up. On the other hand the brickyard would have to be very close to the red mud pond to prevent pollution problems from occuring and to keep costs down. Although no brickyard was close enough to the pond, competition coming from several dozen brickyards already operating in the area questioned the feasibility to set up a new one by the pond. As the author learned from one of Guillini's top executives, now leading another company in the industry, one has to provide for a large value added, larger than in brick making, to get started with the utilization of red mud.

On the basis of his previous experiences in ceramics technology, the author, Mr. Ferenc Puskás, set out to develop a method to utilize large amounts of red mud in the production of ceramics. He described this method in a paper that was later awarded a prize in a contest "Utilization of industrial wastes" sponsored by the Hungarian Academy of Sciences in 1977.

The advantages of this method can be summarized as follows.

- A wide variety of products is now possible, including high value-added items such as glazed tiles and frost-proof porous products.

- More red mud (over 5o %) and not just clay but many other materials some of them otherwise useless, can be used to make up the body (industrial residues containing silicates , vulcanic products, rock material normally considered dead in quarry and ore mining, slag from a garbage incinerator, etc.).
- Alternative production methods can be used to sit the product and the available raw materials. Ease and low cost of production are key, low shrinkage during firing, fuel saving rapid drying and rapid firing can be applied readily.

The new method has been patented as an invention in Britain, Australia, the United States and a nmber of other countries. It was also treated in outline in a Hungarian document complied for a UNEP conference on environmental protection for the alumina industry held in Paris, 2o-23 January, 1981. The author was subsequently invited to the Paris conference, where his method won general acclaim and was incorporated into the list of recommendations adopted by the conference. Several delegations were interested in studies geared to the countries' respective conditions.

On the basis of the recommendation of the conference on the initiation of the Jamaican Bauxite Institute the Jamaican government requested UNIDO to prepare a feasibility study and an economic evaluation. The study was completed in 1982-83.
Following the above events several states announced their demand for similar UNIDO studies. In 1983 the Indian Government also requested the author to elaborate technology for the processing of iron-ore washing and gas-washing sludges which are the waste products of direct reductional sponge iron production, for the utilization of building industrial purpose. This work was successfully elaborated in 1984.

In August 1984 UNIDO invited firms to give offer for the utilization of brown mud of Shandong Aluminium Works of China for building material purposes. The commission was given and the feasibility study and economic part was successfully elaborated and completed by Mr. Puskás .

In September 1984 UNIDO invited firms to give offer for the preparation of the present study. The commission was given to the offer submitted by Licencia - containing Mr. Puskás's ceramic expert, proposals.

On the basis of the preliminary document UNIDO approved the plan of work and the calculation of the pilot scale feasibility study.

In the possession of the above references Mr. Puskás undertook to prepare the UNIDO study and pilot scale testing through Messrs. Licencia, using the bauxite residue of KORBA alumina plant and other local low value materials, and conducting pilot scale testing for processability to building-construcion materials for demonstration scale production of bricks, blocks, tiles, etc.

According to the contract between UNIDO and Licencia in this project, a geologist and a chemis visited the project area including New Delhi and Korba. Their work was limited only to geological and chemical work steps, because team leader was aware of the necessary economic information due to the fact that he prepared the project document as well.

The material samples collected on the spot by chief geologist Dr. Komlóssy and chemist, Mr. Gechter were subject to laboratory tests in Budapest and West-Germany resulting the optimation of pilot-scale formulas. 5 tons of the material were delivered to Budapest by Messrs. BALCO.

In conformity with the above thisstudy deals with the quality of the producable goods, the optimation of the manufacturing technologies in respect to the processing possibilities of the red mud of Korba Aluminium Plant, elaborated by Mr. Puskás.

Thus the present Study is concerned with the use of alumina factory red mud for purposes of the building industry specifically in India-Korba. Therefore, results, conclusions and facts established in this paper should not be understood to refer to the alumina industry of any other country only to Messrs. BALCO, Korba, India.

2.2. Project History

After the respective subcontract entered into force, Dr. Komlóssy chief geologist and Mr. Gechter, Chemist, members of expert team received their briefing on the project from Mr. Shen Wenrong, UNIDO, Vienna.

A field trip aimed at the familiarization with the local conditions and selection of the potential additives took place in March 1985.
From the local additives the most appropriate ones were chosen, and taken to Hungary in a quantity of 2,5 kgs.

In Budapest Mr. Puskás tested the samples in short laboratory tests with different components to find out which materials he would like to be included in the 5 tons sample to be sent from Korba to Hungary for pilot scale testing. After determining the best composition in his own laboratory he made tests and firing experiments.

It was then established that red mud of Korba and additives yield mistures which are suitable for the production of floor and wall tiles of the required quality fired out in electric kiln on a temperature of 115o°C.

Following the evaluation of the laboratory tests the author requested Messrs. BALCO to send the following materials to Hungary.

- red mud 2,5 t
- fly ash from the state power station 1,5 t
- mottled clay (plastic refractory, deriving from the Kusmunda coal mine bed rock) o,25 t
- lithomarge o,5 t
- arkosa sand (M-nikpur-Colliary quarry) o,25 t

Subsequent laboratory tests and the pilot demonstration of the dry pressing technology were performed at the Kochel am See facility of Messrs. Dorst Maschinen und Anlagenbau, something that was special importance since this firm had carried out a series of positive experiments in large laboratories and on an industrial scale with Hungarian, Jamaican, German, Chinese and Indian red muds and additives. Also, one of Europe's most advanced pilot plants and test laboratories were built at Messrs. Dorst in the summer of 1982, and not this Indian red mud project was the firs complete job that needed all their equipment to perform.

The production demonstration took place in the middle of December 1985 with the participation of Mr. Shen Wenrong UNIDO official . Unfortunately the Indian delegation was not in a position to take part on the testing and demonstration thefore the demonstration was repeated at the end of June,86 with the participation of BALCO representatives.
Very much indeed was at stake, since the size of the pilot equipment and the amount of material components available allowed for no repetition and even the composition of the mixutre had to bemodified on the basis of the laboratory tests.

The production of various tiles from Korba red mud and additives was successfully demonstrated at the Dorst plant in December 1985. Subsequent reports have been prepared which are presented in further parts of this Report.

Chapter Three

Technical Report

Main oxide components of red mud of BALCO

Fe_2O_3	46,5%
SiO_2	21
Al_2O_3	12,5
CaO	9
TiO_2	2,5
MgO	1,5
Na_2O	2,1
K_2O	0,4
S	0,4
L.O.I.	11

3.1 Geological survey and testing of available raw materials

Laboratory tests

The material samples collected in the Project Area were tested in the laboratory and the results are as follows.

From the mixture of Korba red mud, lithomarge bed rock of Putka Pahar bauxite mine, the refractory mottled clay and the arkosas sandstone deriving from the Manikpur-Colliary quarry architectural ceramics of high quality can be produced.

By using the red mud of Korba and the fly ash of the state power station of Korba (beside the manipulation of fly ash) good quality walling elements can be produced. The fly ash of the state power station can be used without any manipulation after mixing it with red mud and cement for the production of good quality walling elements, by cold technique. The mixture of Korba red mud and fly ash of the state power station resp., the fly ash of the power station of the alumina factory in Korba can be used for agricultural purpose as an effective substance bearing granulated by mixing the additive in the appropriate ratio.

The lime factory of Korba alumina plant can give the suitable quality lime stone granulate for the manipulation of the fly ash of the state power station.
The same relates to the production of the granulate for agricultural purpose (lime stone granulate).
The quality of the mottled clay deriving from the quarry No.3. of Kusmunda is suitable in quality for the plastification of the mixture.

Available additives for the utilization of red mud of BALCO, Korba (India, Madhya-Pradesh) for the building materials industry.

1. Yellow clay (sandy-silty)

Several smaller brick factories are working in the neighbourhood. Their raw materials are the changing sandy-silty clay sorts available in an unlimited quantity on the surfacewhich macroscopically can be easily recognized.

Chemical and mineralogical composition

SiO_2	61.1 %
Al_2O_3	18,7 %
Fe_2O_3	6,2 %
TiO_2	1,o %
L.o.I.	7,9 %
CaO	2,1 %
Na_2O	1,84 %
K_2O	o,38 %

Kaolinite content of the sample is about 37-38 %. Significant quantity of silica is in quartz and feldspars. Iron is bound to pelitic (clayey) fractions, it is in goethite, the hematite plays a subordinate role. The alkalies signalise the presence of feldspars.

2. Coal shists

Alongside the lower Gondwana coal seams in the neighbourhood of Korba coal bearing clay shists can be found. In some places they are micacous, and plastic.

The utilization possibilities will be examined detailed because the quantity of the stocks according to the gological judgement and survey is secured, its mining is simple.

3. Mottled clay

In the overburden of the coal complex suitable quality mottled clay can be found in 2-4 meters depth from the surface for the production of red mud brick. Its thickness is 2 m. In the neighbourhood of Kusmunda quarry No.3. 1oo-2oo.ooo tons were explored up to now. In the explored areas during the following 2-3 years it will be exploited together with the other iverburdens.
The separate exploitation and deposition thereof can be theoretically solved if it is confirmed by the technological experiments.

Chemical and mineralogical composition

SiO_2	52-63 %
Al_2O_3	2o-27 %
Fe_2O_3	3-6 %
TiO_2	1-1,5 %
L.o.I.	8-1o %

As far as mineralogy is concerned the kaolinite content of the clay may varies between 15-25 %. The iron in goethite. Some percent of calcite was also detected by mineralogical investigation. The quartz represents about 1o-2o %.

4. Lithomarge

The geological pro ile of Putka Pahar bauxite mine (3o-35 km) from Korba alumina plant) is as follows.

- laterite soil	o-1 m
- pirolitic laterite	o-7 m (frequently 2-3 m pizolitic laterite)
- bauxite	2-5 m
- ferroginous laterite	1-2 m
- lithomarge	3-4 m (tufaceous clay)
- basalt - deccau trap	

The lithomarge is explored on the border or basalt platos, in nalas, and road cutting. The bauxite mining exploited the ore in several pits, thus by removing the laterite overburden, valuable formation will be available for us. In the natural outcrops about loo.ooo tons can be expected.

Chemical and mineralogical compositions are as follows.

SiO_2	45-5o %
Al_2O_3	15-35 %
Fe_2O_3	7-17 %
TiO_2	o,9-1,6 %
L.o.I.	12-15 %

Comparing with other types of lithomarge one of our samples was extremely rich in silica and poor in alumina. As the silica content significantly surpass that of alumina, it means the remarkeble quantity of non-altered rock fragmants. Kaolinite content varies between 3o-7o %. Iron is partly in goethite partly in hematite.

5. Arkosa sand

It derives from the denudation of older granite, it is an arkosa sandstone depositing in the high overburden of coal seams, under the surface o,5 - 2,o m , in a thickness of 3-8 m.
(Quarry of Manikpur-Colliary)
The prevailing grain size is between 2-3 m.. More than 6o p.c. of the rock is quartz, the rest is feldspar. This means a SiO_2 content of 75-8o p.c.

Chemical and mineralogical composition

SiO_2	81,8 %
Al_2O_3	9,o
Fe_2O_3	1,6
L.o.I.	2,2

Loss of ignition refers to some percents of kaolinite. The main mineral is the quartz , representing about 6o-65 %, less than lo p.c. is ortoclase feldspar. There are some non-definable rock fragments, too.

Summary

Both the material testing and the experiments regarding the technique are in progress. It is an economical question whether from the additives the mottled clay or the lithomarge will be the most suitable.
It is determined by the further expected explorations, mining and delivery.

5.2

Laboratory investigation of red mud by-product of Balco Alumina Plant and of other waste deposits and mineral resources of Korba area from the point of view of utilization of red mud as the raw material of different constructing matters

Using the red mud waste for the purpose of producing various covering tiles we have taken into consideration red mud samples from different deposit pounds, different kinds of clay containing samples ingathered directly for this purpose on the spot personally, and of a high quartz content overburden deposit near Korba.
In accordance with the preliminary research plans the red mud was used in varying percentage /40-70 %/ in the final composition. At determining this final composition the following aims were respected: to reach the possible highest ratio of red mud at the same time of achieving the optimal quality level of the targeted product, considerating the local circumstances in the point of view of the manufacturing security. By the selection of the other additives the long-term availability of theirs was also regarded.

During the laboratory manufacturing technology quests altering colours of the burnt subjects could have been seen. This fact also showed in accordance with the chemical analyses that the lime content of the red mud samples taken from separate ponds and from the current origin strongly alter.

Optimization of technology

In the first approach 70 % of red mud, 20 % of lithomarge and 10 % overburden of high quartz content were taken. According to our wide knowledge taken from our numerous similar studies preceeding this the fabricating proceeding was the following. The mixture was put into a ball-mill and was ground to fine particle size in wet condition. Afterwards this sludge was dried and granulated to gain a so-called dry press-powder. It's optimal moisture content is around ten percent. If the powder is not dry anough it tends to adhere to the metal plates of the pressing machine. In the case of low humidity the initial strength of the pressed goods will be insufficient, causing demages during processing and gives unwanted influence to the quality of the final products.

Due to the low plastic conent of the first mixture the test showed low pressed strength and faulty products in high ratio as well as unwanted degree of shrinkage of burnt goods and water uptake. On the base of the observation of the first attempt it was advisable to decrease the quantity of red mud parallelly with the increase of clayay and sandy part as well. In the second approach the red mud of 60 percent, the lithomarge of 25 percent and the sandy additive of 15 percent were combined. The technological steps carried out were the same as mentioned previously. The pressed and dried pieces were burnt at a temperature of 1050 °C, considerable improvement could be observed in the security of fabricating of semi-produts, in

distribution of grain size in the granulated press-powder, the strenth of the pressed goods increased, but the quality peculiarities of burnt tiles did not grow significantly yet. The shrinkage during burning and water absorbability was still high.
In this phase of the investigation parallel experiments were carried out in order to replace the lithomarge partly or totally by the "so-called" fire-clay samples taken from North-West front of Kusmunda coal expoitation quarry No. 30. Although this kind of clay shows same advantageous features /i.e. placticity, ability of turning into sludge more easily, diminishing the grinding period e.t.c./ in several stages of working out tended to act unbeneficially and causing inclination to deformation of burnt tiles. Furthermore, because of the uncertain situation in the coal mine exploitation the separation of the clayey part of he overburden seems to be more difficult than mining the better quality lithomarge in a territory belonging to the same enterprize. Despite the above things we want to emphasize that this fire clay may be useful in different purpose and different technology. Having the possession of the hitherto results we altered the composition to the direction of better quality products. In the next laboratory test of getting wall tiles, we fixed the ratio of red mud at 50 percent; the Putka Pahar Lithomarge at 30 percent, and the sandy additive at 20 percent in the mixture. Following the above metnioned procedure

the optimal moisture content of the granule was set. The properties of press-powder reached the maximal requirements in every aspect, the distribution of particle size was optimal and did not change. during the operational steps, neither in space nor in time. It's tendency of crumbling finally stopped, so that the clayey content gained it's optimal ratio. During baking the pressed tiles in electrically heated laboratory kiln at a temperature of 1050 ^oC, inclination to deformation or cracking was not observed. It seemed that this composition is very close to a general purpose covering material for wall tiles as well as floor tiles for interior use. But if targeting a separate wall tile producing line its shrinkage is still a little bit high /about 6.5 percent in laboratory circumstances/. That is why the sandy part of the composition was to be raised to 25 percent, while the red mud ratio was reduced to as low as 45 percent. The clayey additive remained at the necessary and adequate 30 percent. The contraction fell down to a satisfactory level of about 5 percent. The physical features of the tiles /hardness, strengths both bending and pressing can be compared by the Hungarian and international standards and prescriptions. Further efforts were done to lessening the contraction by increasing the silicate content. The further results gained by this way were not preferably comparable to its financial drawbacks. So it can be stated that the 25 percent of the given sandy additive is the upmost ratio in use.

It has to be emphasized that this ratio of the composing raw materials need a single firing process, if the tiles are glazed because of the high silica content, but as it is world wide known nowadays the single firing process is always more advantageous economically than the double one.

When a separate floor-tile producing plant is required the composition has to be preferably changed. Gaining a higher density of the body the baking temperature should be higher by about 30-50 degree. It could be reached through a greater measure of contraction what was carried out by cutting down the ratio of sandy additive and parallelly rising up the percentage of red mud. As it was mentioned before the 30 percent of clayey part is the optimal. Gradually changing the ratio of those components it is found that 55 percent of red mud can be regarded as maximum, that means that the sandy additive originated from a spoil-bank occures in 15 percent as a minimum.

3.3

Strength testing of walling elements made of red mud and fly-ash both of Indian origin

Aim of the testing was to investigate the feasibility of the manufacturing of walling elements meeting the strenght requirements made of the mixture of red mud and fly-ash by cálcium-hydrate binding material.
The strength testing was carried out according to the prescriptions of the Hungarian Standard No. 523/4.
Deviations from the Standard are as follows:

- The binding material is not cement but calcium-hydrate.
- The grain size of red mud and fly-ash is under 300 /um.
- The ratio of the components were determined according to the table No 1, thus the stipulations of the Standard regarding cement mortars were not followed.

Testing method

The mixture was made according to the ration given in the Table No 1. From the mixtures composition was made by adding 30 per cent water, by using the mixing equipment stipulated in the Standard. From this mass elements of 40x40x160 mm size were shaped. The elements had been left in room temperature for 24 hours for strengthening, then had been put into autoclave to reach the final strength.
Parameters of the autoclave are as follows:

- steam pressure 10 kp/cm^2
- duration 8 hours

The strengthened probe bodies were dried on a temperature of 106 °C to reach their final weight then the bending and compression strength were measured according to the method prescribed in the Standard.

Measuring data are summarized in Table No 1.

Statements

On the basis of the testing the following statements can be considered;

- The Standard testing method is suitable to get adequate information on the mechanical strength of mortar type materials in the present case of red mud masses. We consider it necessary, however, to justify the building technological suitability of the product quality on the basis of the tests.
- By increasing the calcium-hydrate content the compression strength also increases. It can be stated that the rate of increase is not proportional to the change of calcium content. By increasing the calcium-hydrate content from 10 per cent to 20 per cent the compression strength can be increased to almost its double. Beside 30 per cent calcium-hydrate content the measured compression strength practically does not differ from a 20 per cent value.

- The bending strength of the samples by increasing the calcium-hydrate content shows an increasing tendency
- The volume density of the probe bodies irrespectively of their composition changes between 1300-1400 kg/m^3 which means in comparison to the volume density of a normal clay brick /1700 kg/m^3/ a lower value. The volume density of a fired hollow clay brick is 1220 kg/m^3, that of the walling insulating brick 1320 kg/m^3.

Table No 1

Mechanical Characteristics of Red Mud of Indian Origin

No	Composition	Characteristics	1.	2.	3.	Average
I.	red mud 60 % fly-ash 30 % calcium hydrate 10 %	volume density /kg/m3/	1281,3	1340,0	1297	1306
		bending strength /MPa/	1,09	1,16	1,38	1,21
		compression strength /MPa/	6,80-7,60	6,40-6,00	6,40-6,80	6,66
II.	red mud 50 % fly-ash 30 % calcium hydrate 20 %	volume density /kg/m3/	1379,0	1367,2	1441,4	1385,8
		bending strength /MPa/	1,22	1,21	1,22	1,21
		compression strength /MPa/	14,80- -14,40	13,20- -14,00	14,[illegible]0- -14,00	14,13
III.	red mud 40 % fly-ash 30 % calcium hydrate 30 %	volume density /kg/m3/	1300,8	1308,6	1308,6	1306
		bending strength /MPa/	2,49	2,55	2,68	2,57
		compression strength MPa/	16,4- -16,00	15,6- 15,20	13,60- -13,20	15,00

3.4.. Pilot scale production demonstration in Hungary, Kiskunhalas brick factory

On the occassion of the visit of BALCO representatives between 23 June - 9 July 1986. pilot scale production demonstration was organized in Kiskunhalas lime-stone brick factory in Hungary on 2nd July 1986.

The composition of the mixture used for brick production was the following:

500 kgs red mud
400 kgs fly ash
100 kgs lime

After an intensive mixture of the components with water in a ratio of 15 p.c. bricks were pressed by a specific pressing force of 100 kp/cm2. The bricks were packed on hardening cars, and were delivered to the autoclave. The treatment in the autoclave was made by 12 at pressure, temperature of steam was 180 ^{o}C, with a duration of 7 hours. The strength value of the finished product was 100 kps.

It is to be remarked that the material composition was inhomogeneous, therefore, the real strength value had not been achieved due to the fact that the adding of lime was made in the form of lime hidrate instead of calcium oxide because the composition could not go through the whole line.

According to the experiences better results can be achieved if calcium oxide is used in the composition where the lme is slacked in the reactor.

After preparing this mixture in laboratory additional testing was made where the results confirmed that under suitable circumstances bricks of optimal characteristics can be achieved.

3.5.

TEST REPORT

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on the production of ceramic tiles from a body with red mud components in single firing.

Carried out for:

Licencia, Budapest

team included Mr. F. Puskas, ceramic expert, team leader

M.V. Pap, project coordinator

Mrs. Batri, Project consultant

by:

DORST Maschinen und Anlagenbau

Mittenwalder str.61.POB 109+129

D-8113 Kochel am See

DORST team included: Mr. Roschlau, leader of laboratory

Mr. Gräf, ceramic engineer

27th June, 1986.

With the participation of:

Mr. I.K. Agrawal, Chief Technologist BALCO, India

Mr. Kedarnath, Techn. Manager, BALCO, India

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3. Summary

1. Scope of order

The aim of the visit of the Licencia team was to investigate the possibility of production of tiles from a ceramic body with red mud components. A batch consisting of three raw materials was to be processed as follows:

- preparation by means of wet-grinding mills,
- spray drying of the slip
- pressing of tiles with this granule and subsequent drying,
- glazing of the dried tiles, and

firing of the glazed tiles

The tests have been carried out in the Test and Research Centre in Kochel am See from 23rd to 27th June, 1986., under the supervision of Licencia team, and with the participation of BALCO delegates, India.

2. Performance and results

2.1. Body preparation

For the trial the following raw materials had been placed at disposal:

23o kg red mud	(approx.	45 p.c.)
14o kg sand (arcosa)		3o p.c.
13o kg lithomarge		25 p.c.
236 kg water		

The raw materials had been weighed and ground in two batches of each 25o kg with 118 l of water in a wet-grinding ball mill (Dorst NM 11o/9o)

Dorst Company placed at disposal the liquifying agents Giessfix C 3o and Dolapix PC 67. Hence, both batches were liquifying with o,1 p.c. of Dolapix PC 67 and o,25 p.c. of Giessfix C 3o. The grinding time for each batch six hours. After this period of time the residue was smaller than 5 p.c. on a sieve with 63 µm mesh aperture.

The slip ground in two batches was subsequently put into a container with electric stirrer and kept in constant elutriation until the spraying was effected in the spray drier.

2.2. Spray drying

By means of a diaphragm pump (Dorst MPz 8o/25 R) the prepared slip was pumped to the spray drier (Dorst D 4oo) which has a water evaporation capacity of 4oo l/h. The entire slip was sprayed into the tower with a nozzle (ø 1,9 mm) whereby the air entry temperature in the tower was 35o °C.

The heating medium was liquid gas and the pre-heating of the air was done b y an integrated heat exchanger.

All technical data as to the spray drying have been listed in annex 1. The sieve analysis of the granule revealed that the main range of the granule distribution is at 2oo to 315 µm. This distribution being very favourable for pressing had been achieved by the fact that the spray drier has an automatic dust recycling, i.e. small particles which are swept out of the tower with the exhaust air can be separated by means of a cyclone.
The separated particles are transported into a pressure line with which the dust is blown into the tower again near the spraying nozzle. Thus an additional agglomeration of the dust particles is achieved so that the very fine proportion of the granule remains relatively small.

In the spray drier approx. 5oo kg of pressing granule with a residual moisture content of 5 p.c. was produced.

2.3. Pressing

The granule produced by the spray drier was pressed on a fully-hydraulic tile press (Dorst HPP 75o). By means of a three-cavity die (215x322 mm) tiles with an edge length of approx. 217x324 mm were produced. The specific pressing force was approx 29o bar at a tile thickness of 8,5 mm. The adjustment of the various pressing forces at the machine can be calculated from annex 2. "industrial trial on hydraulic plate press HPP 75o."

After pressing the tiles were placed on a perforated metal sheet and were dried over night in a chamber drier at 11o °C.

In summarizing it can be stated that the granule with red mud components has a good pressability and reacts relatively insensitive to change of pOressing force.

2.4. Glazing

For the glazing of the tiles Company KERAprogress placed a liquified glaze at disposal which based on a Circonia frit. This frit was kept in a homogeneous condition by intensive stirring, and shortly before use it was provided with an additive tylosis (2 g/l). The specific weight of the glaze was 15oo g/l.

The hot tiles were removed from the chamber drier and were placed manually on a glazing line. After machine brushing of the tiles the glaze was applied in a cabin with a rotating disc.

By varying the speed of the conveyor belt a glaze thickness on the tiles of approx. 1 kg/m² was achieved. On account of the low slip weight of 15oog/l a very slow speed of the conveyor belt had to be chosen resulting in the fact that a dripping of the glaze from the edges of the tiles could not be prevented. The glaze was fixed by means of heating up with IR-radiation.

2.5. Firing

For the firing tests a RIEDHAMMER sledge kiln with a total length of 16 m was used in our Test and Research Centre. It has to be point out that the firing tests have not been simulated but rather have been carried out on an industrial scale in placing firing material on all sledges of the kiln.

During firing the glazed tiles were placed on Cordierite plates which were supported by a mesh of ceramic pins. The sledges were continuously moved through the kiln with four burner groups heated with gas.
With this arrangement the firing programme can be set by selection of the suitable temperature and the passage time of the tiles .

2.6. Laboratory tests

By means of a three-point testing device the modulus of rupture of the tiles were tested before and after firing. The results have been listed in annex 3.
As to the modulus of rupture in undried green tiles this value has been 8.35 kp/cm². After drying this value has been 12,78 kp/cm².

Semi industrial Trial
Spray drying

Annex 1..
Red - mud test

PROJECT / CUSTOMER : Licencia,Budapest ORDER NO. :
BODY : tiles DATE : 24.6.86.

Solids	5oo	kg		6o	%
Water	236	kg		4o	%
Deflocculant		kg	Dolapix pc 67	o,1	%
Liter weight	1625	g/l	Giessfix C 3o	o,25	
Viscosity	42o	cP			
Residue on					%

Nozzle-upright :	1		Hot air	35o	°C
Number Pcs. :	1		Waste air	8o	°C
Nozzle Diameter :	1,9	mm	Tower	18	mm W.G.
Twisting worm :	S 6/4	mm	Main fan	18o	mm W.G.
			Pump	22	kp/cm2

Residual moisture content : 5%
Bulk density 955 g/l
Granulated material kg/h
Water evaporation kg/h
Consumption of gas m3/h
Remarks

Particle size distribution :

> 500 micron	o,1	%
500 - 400 micron	o,8	%
400 - 315 micron	11,1	%
315 - 250 micron	4o,6	%
250 - 200 micron	26,3	%
200 - 160 miron	9,1	%
160 - 100 micron	9,3	%
100 - 50 micron	2,3	%
< 50 micron	o,2	%

VEZ Laboratory / Pilotplant

Blatt

Semi Industrial Trial on the Hydraulic Tile Press HPP

Annex. 2.

Red mud test

PROJECT/CUSTOMER: Licencia, Budapest

Order no. :

Body : tile body

DATE : 24-6-86.

Granulate moisture content: 5 p.c.

Quantity pressed : 5oo kg

Press die tiles

Size of press die: 215x322

Size of ~~fillers~~ tile

Weight of tile: 1o71 g

215x322 mm

Adjustment of machine: p_1=29o bar, p_2= bar

1st pre-pressing force: F_{V1} =15o t: F_{V1} spez. = N/mm²

2nd pre-pressing force: F_{V2} = t; F_{V2} spez. = N/mm²

main pressing force : F_H =29o bar; =765 t F_H spez. = N/mm²

Time sequence of pressing :

start	stop	function	s	start	stop	function	s
0	0	filler forward 1st fall	16	10	10	2nd pre-pressing	
1	1	filler forward - reverse	4o	11	11	main pressing	
2	2	filler reverse during shaking	32	12	12	delay crosshead upwards	46
3	3	filler return time		13	13	crosshead upwards	
4	4	crosshead downwards		14	14	over-all cycle time	
5	5	additional de-airing T		15	15	filler return 2nd fall	
6	6	delay compacting force		0	3	over-all filler movement	
7	7	1st pre-pressing		6	11	over-all pressing time	
8	8	delay de-airing		4	12	over-all crosshead movement	
9	9	de-airing		/	/	strokes per minute	13,6

Filler: Number of stripes: 7

Filling height: 18 Thickness of ~~filler~~ : of tiles: 8,5 mm

Green bending strength: 7,93 kg/cm²

Annex 3. Modulus of rupture after drying

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size in mm 216 x loo

modulus of rupture

Pmax.	kg	4,4
Ls	cm	15,o
b	cm	216,o
a	cm	o,88
RB	kp/cm²	12,70

P= fracture load

Ls= distance of edges

b = width of tile

a = thickness of tile

$$RB = \frac{3\ Pmax\ Ls}{2\ a^2\ b}$$

3. Summary

The tests carried out, have clearly shown that ceramic-tiles can be produced in a rapid single-firing process by means of using a ceramic body which contains red mud as main component. Also the laboratory tests pointed out that the properties of the produced tiles correspond to the German standards.

The fact that the firing tests were carried out in semi industrial scale test in a sledge kiln with a total length of 16 m only it enables ut to point out, that the firing in a rapid firing kiln is possible. On an industrial tile production line using a roller hearth kiln the tiles can be produced with a better quality due to the more favourable firing conditions.

3.6

Technological description and specification of a brick factory for the production of universal walling blocks on alumina factory red-mud based cold technology with an annual capacity of 10.000.000 pcs with a dimension of 220x110x55 mm, to the feasibility study

Content

1. Introduction, basic data

1.1 Annual gross production of the factory

1.2 Name and dimensions of the product

1.3 Timing of work

1.4 Other initial data

1.5 Main phases of production technology

2. Production technology /technical description/

2.1 Reception and storage of red mud of the alumina factory

2.2 Reception of the fly-ash and storage thereof

2.3 Receipt and storage of lime

2.4 Measuring and mixing of red mud, fly-ash and lime

2.5 Hydraulic pressing of the mixture

2.6 Hardening of the pressed bricks in autoclave

2.7 Storage and delivery of finished product

3. Technical data

3.1 Production data

3.2 Material demands /red mud, fly-ash and lime, water/

3.3 Energy demand /fuel oil, electric energy/

3.4 Staff demand

3.5 Storage capacity

1. Introduction, basic data

Our offer was elaborated with due consideration of the general settlement possibilities.
On the basis of our local survey we contemplated to get the red mud from the mud pond near to the alumina factory, it goes to the drying area by pumps of high pressure in pipe-line where it is dried out by waste gases /favourably by flue gase/, finally it is sieved and conveyed to the brick production. The fly ash and lime are delivered to the factory by tank-vehicle, on public road.

The elaboration of technology process, and the selection of machines and equipment was done on the bais of the available information on the raw-materials and tests were carried out with these materials.
The following initial data were taken into consideration regarding the production technology.

1.1 Annual gross production of the factory

At the calculation of the annual gross production of the factory we assumed to produce maximum quantity of building material on the lowest investment costs without giving any compromise in the quality of the manufacturing equipment or in the technology process.

1.2 Naming of the product and dimensions

The product produced has been yellow-reddish solid red mud brick in one size, 220x110x55 mm.

1.3 Timing of work

Number of annual working days	300
Number of working days per week	7
Number of daily shifts	2-3
Effective working hours	7,5 hours per shift
Working in two shifts per day	raw material delivery
Working in three shifts per day	measuring, mixing, pressing, hardening in autoclave, handling of the finished product and energy supply

1.4 Other initial data

- The settlement of the factory buildings can be made by turning away the axis A and B, if necessary. Thus, according to the local conditions the optimal settlement can be planned.
- The economic efficiency can be increased without any limitation because the net production of the factory and the timing of work can be raised if we increase the number of staff and if we apply additional equipment.
- The planning of the internal road network of the factory

makes it possible that the raw material delivery and finished product delivery do not traver 'intersect/ each other.

- The heating value of the available fuel, coal:
  5.2oo kcal/kg, i.e. 22 234 kJ/kg

We assumed that the oil supply is secured at the fence of the plant, therefore, only interconnecting pipes, oil reception station and the pipe-line inside the plant are to be built.

- The transformer station is built inside the plant, it connects to the external network by 2 pcs overhead line of 30 kV.
- Water supply available at the fence of the factory
- Compressed air supply is secured by the planned air compressors.
- Separate laboratory is not planned. Strength tests of the brown mud powder, fly ash, and finished product can be made on the equipment placed in the workshop.
- Regarding the complementary secondary establishments we meet only the most necessary demands with the planning of washing and catering.
- Regarding offices only the absolutely necessary demands are met.
- Regular maintenance is planned only for hardening carriages.
- Measuring and control equipment will be placed in the workshop, in the airconditioned small premises beside the reactor.

1.5 The main phasis of the production technology

- The red mud and the fly ash is delivered on a conveyor , to the plant and is storaged under shelter against rainfall /practically in spaded-finish silo bunkers/.
- The lime is delivered to the plant on a tank car in dry condition, storage: in cement silos.
- Measuring of the red mud, additives in the appropriate ratio, the automatic moistening, the intensive rapid mixing are carried out, the mixture then goes through a double-axe trough mixer to the front loaded hydraulic press. After the automatic loading to the hardening carriage the pressed bricks go through the waiting tunnel to the steam heated autoclaves, then for delivery or to the open-air storage area.

2. Technical description of production technology

On the basis of the initial data the production technology consists of the main phasis as follows:

2.1 Receipt of red mud and storage thereof
2.2 Receipt and storage of fly ash
2.3 Receipt and storage of lime
2.4 Measuring of red mud and fly ash, mixing
2.5 Pressing the mixture into bricks
2.6 Storage of finished products or delivery

Hereinafter we outline the technology process according to the above production phases:

2.1 Receipt of red mud and storage thereof

The tipping ear car full with red mud / pours its charge to one of the bunkers of 18 m^3 /10/ in the covered storage area.
From the covered bunker the red mud is picked up by a handspike front elevator and is conveyed to the fedding bunker. The steel-plate bunker sunk under the level has two outlets, discharge is made by an electromagnetic vibration loading tray, each /11/. Discharge is promoted by a plate vibrator fixed on the side wall of the bunker.
The vibration charger charges the mud to a rubber-textile

conveyor belt /12/, which deliveres it to the scale tank /15/ staying on a steel construction.

2.2. Receipt and storage of fly ash

The fly ash is delivered to the brick factory by conveyor. The discharge resp. the pouring into the cement silo of 29o m3 is made by a pneumatic conveyor being on the car. The filling capacity of cement silo is for 11 days' fly ash demand. From the big cement silo the fly ash is conveyed pneumatically according to the demand in smaller cement silos of 25 m3 /13/ and from here by worm feeder /14/ to the cement scale /17/ tank in the mixing hall.

2.3. Receipt and storage of lime

The lime is delivered to the plant on tank in dry condition, storage: in cement silos.

2.4. Measuring of red mud, fly ash and lime, mixing

The puffer tank above the red mud scale in the mixing hall is feeded by a conveyor belt /12/. The measuring is started by a controller from the control point. The weight to be measured can be adjusted on the control table, thus the filling and discharge of the scale is automatic. The measuring capacity of the red mud scale /15/ has been 2000 kg.

The mud goes from the scale tank by gravity to the intensive reversed current rapid mixer /18/ under the scale. The fly ash, limeto the cement measuring tank /17/ of 0,4 m^3 into the mixing hall by worm feeder. The measuring capacity of the cement scale has been max. 400 kg. After finishing the measuring the fly ash goes by gravity to the reversed current intensiv rapid mixer /18/. The mixing process continues automatically after starting the measuring if the conditions are given:

- the mixer is operating
- the door of the mixer is closed
- measuring of the mixture is finished
- the bunker under the mixer /19/ is not full.

After the simultaneous measuring of fly ash, lime and mud powder dry mixing is made then after automatic water addition /16/ homogenization is the following step.

Max. filling charge of the pre-mixer:	2000+400+2400 kg
Operating charge of the pre-mixer:	2000 kg
Number of mixing per hours:	12,5
Mixing capacity:	12,5x2,0 = 25 t/h

Mixing cycle time is approx. 4,8 min.

After finishing the mixing the homogenized mixture goes to the mixture bunker of 2 m^3 under the mixer /18/, then a cellular feeder /19/ feeds it to a conveyor belt /30/, from where it goes by gravity to the double axe trough mixer /32/ of continuous work for the purpose of second mixing. Here further water quantity will be added /33/ for the adjustment of the most appropriate water content necessary to the pressing. The quantity of lime within the mixture can be altered in the function of the required strength.

As a rule, the mixture consists of 40 w.p.c. but it can reach the 50 w.p.c. as well in the bricks of high strength. Keeping the optimal quantity of the water added is very important because this significantly influences the strength of the product after pressing. The excessive adding of water causes problems with the filling of the press forms and in the course of the hardening in the autoclaves.

2.5 Hydraulic pressing of the bricks

From the double axe trough mixer the powder is delivered by a conveyor belt /34/ to the feeding hopper /40/ of the hydraulic press /40/ of 1 m^3 and of 500 tons pressing force, and from here to the press dies. The level indicator built in the feed hopper stops or starts automatically the conveyor belt and the trough mixer, according to the filling level.

The height size of the brick can be regulated by the bulk of filling volume.

The pressing procedure consists of 4 basic steps:

- filling of the press form
- pressing
- dejection of the brick from the form
- loading of the pressed bricks to the hardening carriage.

The specific pressure of the hydraulic press on the surface of the brick has been 300 kp/cm^2. The press is only then working if there is mixture in the feed hopper and if the hardening carriage is ready for loading at the loading machine belonging to the press. To achieve the required production 4 pcs hydraulic presses are necessary /capacity data of the presses can be found in point 3.2/.

Length of hardening carriage: 1360 mm
Length of the autoclave: 22,5 m
Number of hardening cars in one autoclave: 16 pcs
The filling diagram of the waiting tunnel and autoclaves is shown on the fig. enclosed.

Autoclave length:	22,5 m
Filling capacity:	16 pcs hardening car
Autoclave cycle time:	7 hours

The pressed bricks are picked up from the press table by a pneumatic catch and according to the pre-programmed data it places the bricks to the hardening cars /44/ on the two sides of the press according to the cross-section sizes of the autoclave /47/. During the loading, the moving of the hardening car is made electronically on the tracks, i.e. to the place of the loaded carriage the empty one automatically enters. The automatic loading of the hardening carriages can be preprogrammed according to the bricks of two different height sizes. The number of hardening cars to be loaded: 6,79 pcs per hour.
The waste developing at the press is conveyes through the collecting hopper by a chain link transporter /60/ and a conveyor belt /61/ and gets back to the double axes trough mixer.
After loading the hardening carriage with the fresh pressed bricks, the pusher pushes electromechanically the car into the waiting tunnel. The legnth of the waiting tunnel is identical with that of the autoclave, i.e. it corresponds to the length of 16 pcs hardening carriage / 22 m/. Before the autoclave there is a waiting tunnel. For the hardening we planned 1 pc autoclave, with 16 hardening carriage per autoclave. The filling time of the waiting tunnel has been /in full length/ 2 h 30 min. Consequently, in each shift1,6 pcs waiting tunnel equivalent hardening car get into the autoclave

As one autclave and as per day 51,2pcs hardening car-charge will be hardened. The moving of the carriages insures the defectness of quality of the goods dues to their vibration-proof and careful operation.

Note:

In the selection of the hydraulic presses the following facts were taken into consideration:

- Amont the SS-type hydraulic presses there are a lot in operation, well proved equipment.
- The single sidepressing means a machine of lower costs, it is less complicated, consequently its maintenance is simple, its operation is easier due to its endurance.
- Maintenance demand of the mechanical presses are higher because they have more moving parts in where material granules can get. The mechanical presses in Western-Europe were replaced by hydraulic ones as per offered by us.
- With the mechanical presses the conversion to the production of brick of different sizes requires long lasting work with a specialized knowledge.

2.6 Hardening of bricks in autoclaves

From the waiting tunnel 16 pcs hardening carriages are pulled into the autoclave by wire winch /49/ in one cycle. If the 16 pcs hardening carriages are pulled into the autoclave, if it is closed on both ends and begins the filling up with saturated water steam. The process of increasing, holding and decreasing of the steam pressure is carried on according to a determined program. The hardening time is 7 hours. During the hardening time developes the specified compression strength of the brick.

After finishing the hardening process the steam is passed through another autoclave being under filling up. The doors of the autoclave are opened and the whole carriage-line in the autoclave is conveyed to the storage track beside the drained finished products. Each autoclave has a separate storage track. The tracks /46/ of the hardening carriages are delivered to the plant prefabricated marking the jointing elements. The tracks of the sliding platform are to be set in and fixed to the appropriate track distance on the spot.

2.7 Storage and delivery of the finished product

From the autoclave to the 2 storage tracks the goods are taken out by a grab /48/ of the mobil portal crane of 14 m span and are placed to the storage area or are loaded to vehicles. Above each other 4 charges can be placed at the most.

The crab way of the portal crane on the discharge-side of the hardening carriage has been 5,6 m on the loading-side 4 m with cantilever execution. The working length of the crane has been 80 m.

The empty hardening carriages go by a manual pushing plate /45/ to the hardening carriage cleaning equipment /87/, here the platform of the carriage is cleaned, then the cars through the storage track and manual pushing table go back to the right or left side of the loading track.

3. Technical data

3.1 Production data

3.1.1 Name of product: cold-bond red mud brick

3.1.2 Nominal capacity of the plant: 10..000.000 pcs brick

unit c 15.000 m3

3.1.3 Size of the product: 22ox11ox55 mm

Maximal breaking strength: 1oo kp/cm^2

3.1.4 Operating time, operating program:

number of effective working hours:7,5 hours per shifts /theoretically 8 hours/

number of shifts: material delivery and storage: 2 shifts/day;

measuring, mixing, pressing, hardening, finished products treatment, energy supply: 3 shifts/day

number of working days per week: 6

number of working days per year: 300

number of working weeks per year: 50

3.1.5 Production data /with nominal capacities/

size of brick: 22ox11ox55 mm

number of stroke of the press per hour: 380

brick pc per stroke: 6

brick pc per hour: 2280

volume of 1 pc brick /m^3/: 133

1 m^3 per brick pc: 752

weight of brick per pc: 2 kgs

average volume weight kg/m^3: 1500

press capacity m^3/h: 2,-

material demand ton per hour per press: 4,4

brick pc per hardening carriage: 393

hardening carriage pc per hour per press: 3,7

In the above calculations we started from the volume weight of the finished product of 1500 kg/m^3.

3.1.6 Yearly production data of the brick factory

In case of production of bricks of 220x110x55 mm the technical /nominal/ capacity:

10 000 000 pcs/year

15 000 m^3/year

20 000 to/year

3.2 Material demand

The data relate to nominal production.

initial data of calculation

- dry red mud content 50 wpc
- fly-ash content: 40 wpc
- lime content: 10 wpc

3.2.1 Specific material demand per m^3 brick

name	unit of measure	
red mud /dry/	kg/m^3	752
fly-ash	kg/m^3	602
lime	kg/m^3	150
water /at mixing/	l/m^3	167,64
water /steam production/	l/m^3	342
water total	l/m^3	510

3.2.2 Material demand for hour, shift, working day, year

name	unit of measure	hour	shift	working day	year
red mud powder	to	2,2	16,5	33	10 000
fly-ash	to	1,77	13	26	8 000
lime	to	0,44	3,53	6,66	8000
water	m^3	5,3	4,0	80	24 000

3.3 Energy demand

Basic data of calculation:

heating value of the coal 5.200 kcal/kg,

i.e. 22 234 kJ/kg

3.3.1 Specific energy demand per m^3 brick and per 1000 pcs brick

Brick size in mm: 220x110x55

naming	unit of measure	
coal	kg/m^3	30
	kg/1000 pcs	45
electric energy	kWh/m^3	15
	kWh/1000 pcs	22,5

3.2.2. Energy demand per hour, shift, working day, year

naming	hour	shift	working day	year
coal /kg/	20,8	500	1500	450.000
electric energy /kWh/	10,4	250	750	225.000

3.4. Required staff

Labour /handling/	6 persons
Autoclaves loading and unloading	4
Mashine operator and finished product handling	10
Ironworker and electrician	2
Supervisor	1
Engineer	1
Manager	1
Total	25 persons

3.5. Storage capacity

3.5.1.. Red mud /dry 231 tons

This quantity secures 7 days' requirement.

3.5.2. Fly ash: 182 tons.

This quantity secures 7 days' requirement.

3.5.3. Lime: 46,6 tons

This quantity secures 7 days' requirement.

3.7. Technical description of a suggested floor and wall tile manufacturing plant with a capacity of 2 mill sq.m. tiles/y on the data of Messrs. DORST

SURVEY OF INVESTMENT

FLOOR TILE PROJECT

Product	: glazed, single-fired floor tiles	
Output capacity	: 2.000.000 m²/year, saleable ware	
Assortment, assumed	: 50 % 200 x 200 mm	
	50 % 200 x 100 mm	
Weight, assumed	: approx. 20 kg/m² fired tiles, thickness of tile 10 mm	
Working days	: 300/year for mechanical equipment	
	360/year for the kilns	
Working time	: Preparation of body and glaze	- 2 shifts
	spray drying	- 3 shifts
	pressing section	- 2 shifts
	dryer	- 2 shifts
	glazing section and decoration section	- 2 shifts
	kiln plant	- 3 shifts
	sorting and packing	- 2 shifts
Working time of one shift	: 7.5 hours net	
Glaze required, dry	: on average 1.2 - 1.3 kg/m²	
Press body, dry, required, net	: approx. 160 t/day	

Press body, dry, required, gross	: approx.	192 t/day	
Raw materials	: not yet known, for the selection of the mechanical equipment diverse assumptions have been made for the time being.		
Dimensions of the building	: length	approx.	200 m
	width	approx.	80 m
	area of base	approx.	16.000 m²
Current consumption per sq.m. tiles	: approx.		8 kWh ± 10 %
per kg saleable ware	: approx.		0.4 kWh ± 10 %
Consumption of termic energy per sq.m tiles	: approx.		35000 kcal ± 10 %
per kg saleable ware	: approx.		1750 kcal ± 10 %
Consumption of water per sq.m. tiles	: approx.		30 liters ± 10 %
per kg saleable ware	: approx.		1.5 liters ± 10 %
Labor required	: approx.		200 persons

Description of the technology

We proceed on the assumption that all hard raw materials will be supplied in pre-crushed state, grain fraction smaller than 1 mm, and all medium-hard clays in pieces of smaller than 50 mm. Thus, the grinding period for one charge of the body can be assumed with 12 hours, the grinding period for one charge of the glaze can be assumed with 30 hours. The grinding fineness is to amount to 3 % residues on a sieve with a mesh width of 100 micron. The assumed water contents of the body and glaze slip amounts to 40 %.

The individual raw materials stored in boxes are filled in a box feeder equipped with a weighing device by means of a shovel loader. After the body components have been weighed corresponding to 1 mill charge they are transported to the body preparation by means of a conveyor belt system.

The body components coming from the conveyor belt system are ground in wet-grinding ball mills, together with water and suitable liquifying agents. By means of compressed air discharge this slip is conveyed over box screens for coarse screening into intermediate containers which have been equipped with screw blungers. ~~In~~ these intermediate containers the tile scrap in green and dried state is stirred with water and mixed with the ground slip. By means of diaphragm pumps, the slip is transferred to vibrating sieves, for fine sieving, which have been equipped with magnet filters for the elimination of iron particles. After sieving the slip is transferred to storage containers equipped with slow stirrers.

Diaphragm pumps pump the body slip to the spraying nozzles of the spray drier plant. The slip is sprayed into the spray drying chamber and is dried to pressable granule. The granule leaving the spray drier plant is transported to the storage silos via a sieve and via a transport system consisting of belts and a bucket elevator. The distribution of the granule coming from the silos to the presses is also effected by conveyor belt system.

The press granule is pressed to tiles of different sizes by means of fully hydraulic tile presses. The pressed tiles are subsequently cleaned by fettling machines. Thereafter they are transported into rapid driers and dried to a residual moisture of below 1 % whereby they also obtain the necessary mechanical strength and the temperature for the subsequent glazing and decorating process.

By means of a platform scale the individual glaze raw materials are weighed to a glaze batch and this is transported to the ball mills. After grinding with water and additives the glaze slip is pressed into intermediate containers equipped with slowly stirrers, for quality check. The examined glaze slip is discharged into a storage container equipped with slow stirrer and magnetic rods for the removal of iron particles. Subsequently the glaze slip is pumped into mobile containers via vibrating sieves and via permanent magnets for the separation of iron particles. After stirring in the glaze a glue-water mixture the containers with the final glaze slip are moved to the consumers at the glazing lines.

The dried tiles are provided with different coloured glaze and decoration effects automatically on the glazing lines.

In order to adapt the 2 shift tile production to the 3 shift kiln operation including week-ends a storage of the glazed and of the fired tiles is necessary in a storage and buffer system.

The tiles are fired in a single-layer tile carpet in a rapid firing roller kiln.

The ware coming from the storage plant for fired tiles is transported to sorting units, and separated into the quality groups. Thereafter the tiles are transported to the packing units.

In order to guarantee a constantly good quality of the product and for checking the production quality a works- and a test-laboratory have been proposed.

PROPOSED TECHNOLOGY

The various raw materials for the tile body composition, which is composed mainly by red mud , a waste product which results from BALCO production , are processed by wet grinding process so that a sprayable ceramic slip is obtained.

Details about this technology and about the necessary equipment which according to your wishes you want to procure locally will be informed by the know-how supplier M/S Keraprogress. We are ready to assist and collaborate with the know-how supplier in this context.

The obtained ceramic slip body will be pumped by high pressure diaphragm pumps to the spraying nozzles of the spray drier plant. The slip is sprayed into the spray drying chamber and is dried to pressable granule. The granule leaving the spray drier plant is transported to the storage silos via sieve and via a transport system consisting of belts and a bucket elevator all locally supplied. The distribution of the granule coming from the silos to the presses is also effected by conveyor belt system of local supply.

The press granule is pressed to tiles of different sizes by means of fully hydraulic tile presses. The pressed tiles are subsequently cleaned by fettling machines, and conveyed to the rapid dryers, where the tiles are dried to a residual moisture content below 1 %. By this process the strength of the tiles is increased and the tiles are heated up, which is necessary for the subsequent glazing and decorating process.

By means of a platform scale the individual glaze raw materials are weighed to a glaze batch, which is transported to the wet grinding ball mills. After grinding with water and additives the glaze slip is pumped into intermediate containers equipped with slowly running stirrers, for quality check. The examined glaze slip is discharge into a storage container equipped with slowly running stirrer and magnetic rods for the removal of iron particles. Subsequently the glaze slip is pumped into mobile containers via vibrating sieves and via permanent magnets for the separation of iron particles. After stirring the glaze a glue-water mixture is added and the containers with the final glaze slip are moved to the consumers at the glazing lines. As informed all glaze slip preparation equipment will be of local supply.

An engobe slurry is prepared by stirring china clay into water. The engobe slip is then screened into containers and moved to the engobing stations at the glazing lines.
The predried tiles are provided with different coloured glaze and decoration effects on the glazing lines automatically.

In order to allow an uninterrupted kiln operation a storage and buffer system has been provided for.

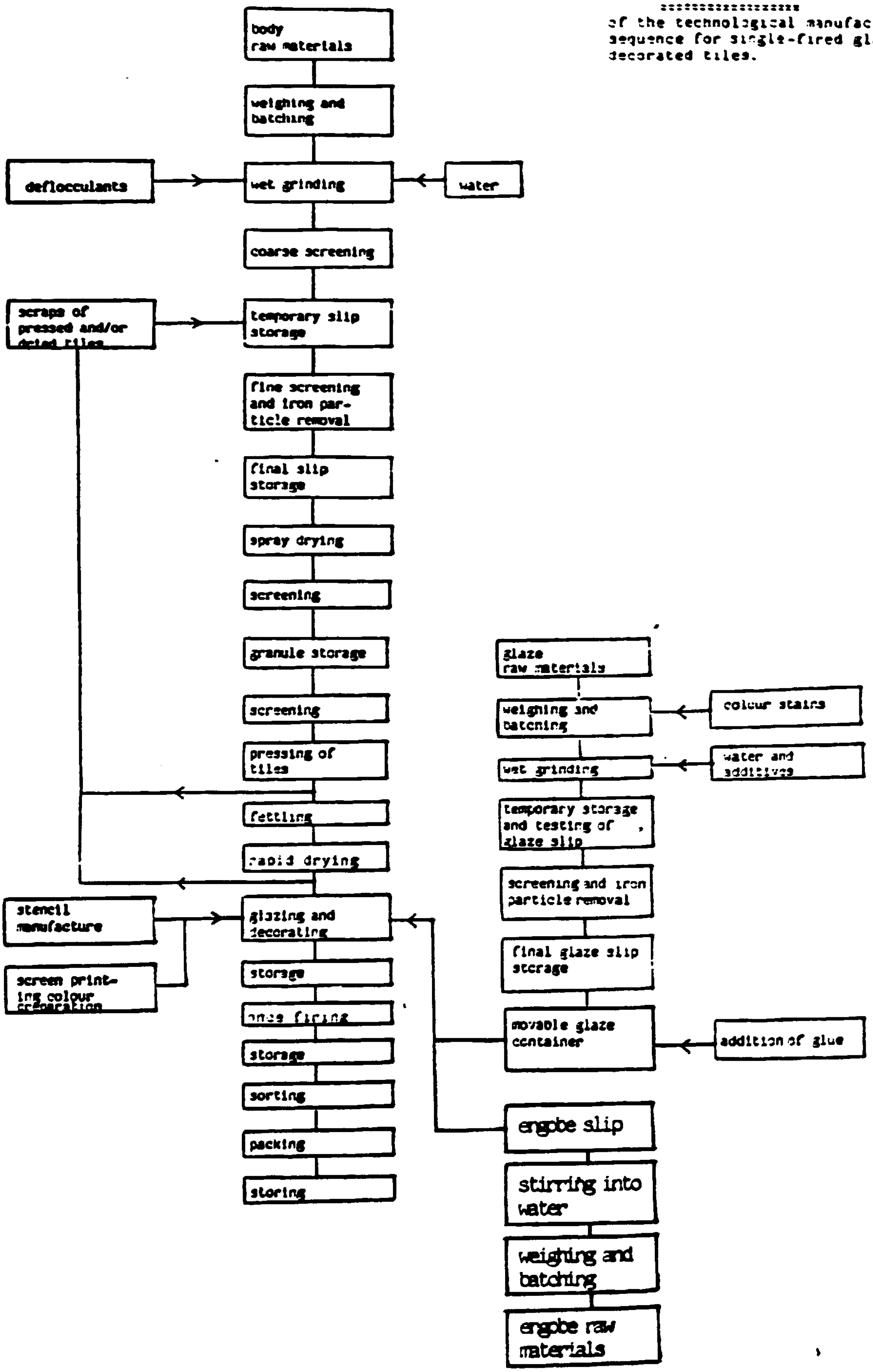
The glazed tiles stored in containers are transferred to the rapid firing roller kiln and fired in a single-layer tile carpet. After firing the tiles are restored in containers.

The ware coming from the storage plant of fired tiles is transported to the sorting lines and separated into quality groups. Thereafter the tiles are transported to the packing units.

In order to guarantee a constantly good quality of the product and for checking the production quality a works- and a test-laboratory have been proposed.

FLOW SHEET

of the technological manufacturing sequence for single-fired glazed and decorated tiles.



Chapter Four

Financial and Economic Evaluation

4.1. Unglazed tiles

4.2. Glazed and decorated single fired floor and wall tiles

4.3. Glazed and decorated tiles for red mud based technology
Predesign estimate, annual capacity 2 mill sq.m.

4.4. Walling brick /total investment cost/

4.5. Walling bricks /predesign product cost estimate/

4.5.1. Walling bricks /profitability/

4.5.2. Walling bricks /cash flow/

The objective of the financial and econimic evaluation in the present Study is to provide a predesign estimate about the profitability of the possible utilization of the BALCO wastes identified earlier. To this end estimates have been made and are presented below of the total investment costs, of production costs and of the profitability of the individual plant/product alternatives described in the Plant Capacities Section, and their cash flow is predicted.

In the Total Investment Tables land and yard improvement have not been costed as BALCO is expected to provide these free of charge. Building costs are estimated using Indian analogues. Equipment and kiln costs are based on price information received from suppliers of industrial machines /Messrs. KERABEDARF of West-Berlin, Messrs. DORST of West-Germany, and Messrs. KERAprogress of Hungary, e.t.c./ and from other sources. The production cost estimates are based on the relevant data of the Project Document and on unit cost information received from officers of BALCO and other Indian sources. The wastes have not been costed except for char which seems to have a market value. The plant site location is assumed to be BALCO yard KORBA or close to it. Depreciation is calculated in a uniform manner to keep things uncomplicated at this stage.

Profability calculations have been made with selling price alternatives to show the sensitivity of the rate of return to changes in the selling price. Further investigations and considerations will be necessary to determine the most probable selling price for the individual products.

The economics of the various product/plant alternatives can be compared using the Profitability Tables. The calculations are based on the assumption, that a 12 % interest loan would be available to the investor in 1:1 ratio to his equity. It was not felt appropriate at this stage to consider the possible effect on the profitability of Corporate tax nor that of any excise duties.

It has not been the aim of this Study to recommend a specific alternative for implementation as such a decision will have to be made by those involved in financing it. It is felt, however, that each alternative has a money making potential besides their common benefit of consuming otherwise useless waste.

4.1.

Unglazed tiles /predesign production cost estimate/

Product weight: 30 kg/sqm.

Product size: 200 x 200 x 15 mm

	Rs.	Rs.
A. Raw material		
1. Red-mud - 2500 tons - Rs. 600/t	1,500,000	
2. Lithomarge - 1500 tons - Rs. 20/t, ex works Korba	30,000	
3. Arcosa-sand - 1000 tons - Rs. 20/t, ex works Korba	20,000	
4. Subtotal		1,550,000
B. Utilities		
5. Light fuel oil - 720 tons - Rs. 3000/t	2,160,000	
6. Power - 750,000 kWh - Rs. 0,5/kWh	375,000	
7. Water - 4500 cu.m. - Rs. 1/cu.m.	4,500	
8. Subtotal		2,539,500
C. Labour required - 20 persons -		
9. Rs. 900 a month/pers.	216,000	216,000

	Rs.	Rs.
D. <u>Miscellaneous</u>		
10. Maintanance and repair		
2 % of building cost	31,500	
5 % of equipment cost	468,750	
2 % of kiln cost	62,500	
11. Insurance and other cost		
1 % of total investment	192,025	
12. Depreciation		
3 % of building cost	47,250	
5 % of kiln cost	156,250	
7 % of equipment cost	652,250	
13. Overhead /administrative and selling/ 7 % of annual sales	1,050,000	
14. Interest		
12 % on 50 % of loan /Rs. 10,000,000/	1,200,000	
15. S u b t o t a l		3,864,525
16. T o t a l annual cost of operation		8,170,025

4.1.2.

Unglazed Tiles /Profitability/

	Rs.	Rs.
1. Gross annual revenue from sales if 150,000 sqm. unglazed tiles for industrial use Rs. 100/sqm.	15,000,000	
2. Annual cost of operation /see item 16 of 4.1.D./	8,170,025	
3. Annual gross profit		6,829,975

4. Rate of return of capital outlay /excluding loan/ Rs. $\frac{6,829,975}{10,000,000} \times 100\,\% = 68.3\,\%$

5. Pay back period 1.46 years

Unglazed Tiles /cash flow at Rs. 100/sqm./

1. Gross profit /see item 3 of 4.1.2/	6,829,975
2. Depreciation /see item 12 of 4.1.D./	859,750
3. Annual repayment of loan principal of Rs. 10,000,000 in 7 years	1,050,000
4. Net cash flow /1. 2. - 3./ in any one production year	6,639,725

4.1.3.

Unglazed Single Fired Floor and Wall Tiles for red-mud technology for Industrial Use /Predesign estimate/

Annual capacity 150 000 sqm.

	Rs.	Rs.
A. Site, buildings, etc.		
1. Land available by Messrs. BALCO		
2. Raw materials storage area 500 sqm. Rs. 150/sqm.	75,000	
3. Plant building, complete with lighting and utility connections 1000 sqm. Rs. 1500/sqm.	1,500,000	
4. S u b t o t a l		1,575,000
B. Machines and equipment		
5. Plant machinery	9,375,000	
6. Kiln	3,125,000	
7. S u b t o t a l		12,500,000
C. Other pre-production capital costs		
8. Engineering	60,000	
9. Ceramic know-how	600,000	
10. Technical assistance, supervision	60,000	

	Rs.	Rs.
11. Contingency, 10 % of A&B	1,407,500	
12. Working capital, 20 % of annual sales /of Rs. 15,000,000/	3,000,000	
13. S u b t o t a l		5,127,500
14. T o t a l Capital Requirement		19,202,500

4.2.

Glazed and decorated Single Fired Floor and Wall Tiles

/Predesign Production Cost Estimate/

Product weight: 20 kg/sqm.

Product size: 200 x 200 x 7,5 mm

200 x 300 x 7,5 mm

	Rs.	Rs.
A. Raw material		
1. Red-mud - 22,000 tons - Rs. 937,5/t	20,625,000	
2. Lithomarge - 13,200 tons - Rs. 20/t	264,000	
3. Arcosa-sand - 8,800 tons - Rs. 20/t	176,000	
4. S u b t o t a l		21,065,000
B. Utilities		
5. Glaze - 2750 tons - Rs. 13,450/t	36,987,500	
6. Heating fuel Light fuel oil - 15 000 tons - Rs. 3000/t	45,000,000	
7. Power - 7,595,000 kWh - Rs. 0,5/kWh	3,797,500	
8. Water - 45,000 cu.m. - Rs. 1/cu.m.	45,000	
9. S u b t o t a l		85,830,000

	Rs.	Rs.
C. <u>Labour required</u> - 200 persons -		
10. Rs. 900 a month/person	2,160,000	2,160,000
D. <u>Miscellaneous</u>		
11. Maintenance and repair		
2 % of building cost	303,000	
5 % of equipment cost	5,000,000	
2 % of kiln cost	375,000	
12. Insurance and other cost		
1 % of total investment	1,911,400	
13. Depreciation		
3 % of building cost	454,500	
5 % of kiln cost	937,500	
7 % of equipment cost	7,000,000	
14. Overhead /administrative and		
7 % of annual sales	14,000,000	
15. Interest		
12 % on 50 % of loan		
/Rs. 100,000,000/	12,000,000	
16. S u b t o t a l		41,981,400
17. T o t a l annual cost of operation		151,036,400

4.2.1.
Glazed and decorated tiles /Profitability/

	Rs.	Rs.
1. Gross annual revenue from sales if 2,000,000 sqm. glazed and decorated single fired floor and wall tiles are sold at Rs. 100/sqm. /ex works/	200,000,000	
2. Annual cost of operation /see item 17/	151,036,400	
3. Annual gross profit		48,963,600

4. Rate of return of capital outlay /excluding loan/ $\frac{\text{Rs. } 48{,}963{,}600 \times 100\ \%}{\text{Rs. } 100{,}000{,}000} = 49\ \%$

5. Pay back period **2 years**

Glazed and decorated tiles /cash flow at Rs. 100/sqm./

1. Gross profit /see item 3 of 4.2.1./	48,963,600
2. Depreciation /see item 13 of 4.2.D./	8,392,000
3. Annual repayment of loan principal of Rs. 100,000,000 in 7 years	14,000,000
4. Net cash flow /1.+2.-3./ in any one production year	43,355,600

4.3.

Glazed and decorated tiles for red-mud based technology

/Predesign estimate/ Annual capacity 2,000,000 sqm

Single Fired Floor and Wall Glazed Tiles

	Rs.	Rs.
A. Site, buildings, etc.		
1. Land available by Messrs. BALCO		
2. Raw materials storage area 1000 sqm. Rs. 150/sqm.	150,000	
3. Plant building, complete with lighting and utility connections 10,000 sqm. Rs. 1500/sqm.	15,000,000	
		15,150,000
B. Machines and equipment		
5. Plant machinery	100,000,000	
6. Kiln	18,750,000	
7. Subtotal		118,750,000
C. Other pre-production capital costs		
8. Engineering	850,000	
9. Ceramic know-how	2,500,000	
10. Technical assistance, supervision	500,000	

	Rs.	Rs.
11. Contingency, 10 % of item A+B	13,390,000	
12. Working capital, 20 % of annual sales /of Rs. 200,000,000/	40,000,000	
13. S u b t o t a l	57,240,000	57,240,000
Total Capital Requirement		191,140,000

4.4.

Walling-bricks

/Total Investment Cost/

/Predesign Estimate/

Annual capacity: 10 million standard bricks for red-mud based cold technology cold technology

	Rs. thousand	Rs.
A. Site, buildings, etc.		
1. Land available by Messrs. BALCO		
2. Raw materials storage area 1000 sqm. Rs. 150/sqm.	150	
3. Plant building, complete with lighting and utility connections 500 sqm. Rs. 1500/sqm.	750	
4. Subtotal		900,000
B. Machines and equipment		
5. Plant machinery	4,000	
6. Autoclaves	3,000	
7. Subtotal		7,000,000

	Rs. thousand	Rs.
C. Other pre-production capital costs		
8. Engineering	100	
9. Know-how	400	
10. Contingency, 10 % of items A+B	790	
11. Working capital, 20 % of annual sales /of Rs. 4,500,000/	900	
12. S u b t o t a l		2,190,000
13. T o t a l Capital Requirement		10,090,000

4.5.
Walling bricks /Predesign Production Cost Estimate/

Product weight: 1,85 kg

Product size: 220 x 110 x 55 mm

	Rs.	Rs.
A. Raw materials		
1. Red-mud - 10,000 tons dry solids - Rs. 10/t	100,000	
2. Fly ash - 8,000 tons dry solids - Rs. 10/t	80,000	
3. Lime - dry C a0 - 2,000 tons - Rs. 550/t	1,100,000	
4. S u b t o t a l		1,280,000
B. Utilities		
5. Fuel - Coal 450 tons 5200 kcal/kg - Rs. 280/t	128,250	
6. Power - 225 000 kWh - Rs. 0,5 kWh	112,500	
7. Water - 24 000 cu.m. - Rs. 1/cu.m.	24,000	
8. S u b t o t a l		264,750
C. Labour and Supervision		
9. Labour /handling/ 6 persons - Rs. 500 a month/pers.	36,000	
10. Autoclaves loading and unloading 4 persons - Rs. 600 a month/pers.	28,800	

		Rs.	Rs.
11.	Machine operators & finished product handling 10 persons - Rs. 800 a month/ pers.	96,000	
12.	Ironworker & electrician Rs. 900 a month/ pers. 2 persons	21,600	
13.	Supervisor 1 person Rs. 1500 a month	18,000	
14.	Engineer 1 person Rs. 1600 a month	19,200	
15.	Manager 1 person Rs. 2000 a month	24,000	
16.	S u b t o t a l		243,600

D. Miscellaneous

17.	Maintanance and repair		
	2 % of building cost	18,000	
	5 % of equipment cost	200,000	
	2 % of autoclave cost	60,000	
18.	Insurance and other costs		
	1 % of total investment	100,000	
19.	Depreciation		
	3 % of building cost	27,000	
	5 % of autoclave cost	150,000	
	7 % of equipment cost	280,000	
20.	Overhead /administrative and selling/		
	7 % of annual sales	315,000	

	Rs.	Rs.
21. Interest		
12 % on 50 % of loan /Rs. 5 million/	300,000	
22. S u b t o t a l		1,450.000
23. T o t a l annual cost of operation		3,238,350

4.5.1.

<u>Walling bricks</u> /Profitability/

	Rs.	Rs.
1. Gross annual revenue from sales if 10 mill. standard bricks are sold at Rs. 450/1000 bricks, ex works	4,500,000	
2. Annual cost of operation /see item 23 of D/	3,238,350	
3. Annual gross profit		1.261,650
4. Rate of return of capital outlay /excluding loan/ $\frac{\text{Rs. } 1,261,350}{\text{Rs. } 5.000,000}$ x 100 % = 25,23 %		
5. Pay back period	3,96 years	

4.5.2.
Walling-bricks /Cash flow at Rs. 450/1000 bricks/

1. Gross profit /see item 3 of 4.5.1./	Rs. 1,261,650	
2. Depreciation /see item 19 of 4.5.D./	Rs. 457,000	
3. Annual repayment of loan principal of Rs. 5,000,000 in 7 years:		Rs. 700,000
4. Net cash flow /1.+2. -3./ in any one production year		Rs. 1,018,650

Chapter Five

Market Survey of Selected Building Materials

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1.4 Status of Glazes
1.5 Firing Capsules

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4.2 Types of Roofing Tiles

4.3 Demand

4.3.1 Total Demand

4.3.2 Domestic Demand

4.3.3 Exports

4.4 Availability

4.5 Market Potential

5. Floor Tiles

5.1 Introduction

5.2 Demand

5.2.1 Total Demand

5.2.2 Domestic Demand

5.2.2 Exports

5.3 Availability

5.4 Market Potential

<u>Annexures</u>

A List of Parties and Agencies Contacted

B Capacity and Production of Glazed Tiles in India During 1961 to 1981

C Indian Exports of Glazed Tiles by Destination

D Types of Roofing Tiles

E Indian Exports of Roofing Tiles by Destination

1. Introduction

1.1 Assignment

This report was prepared on the basis of the data of Industrial Development Services /IDS/, New Delhi, India.

The aim of this report is to carry out a market survey of the demand for and availability of following specific building materials, separately for the country /India/ as a whole.

A building bricks
B glazed tiles
C roofing tiles
D floor tiles

1.2 Approach

The manufacturing activity in respect of these materials, except glazed tiles, is in the hands of small scale units spread throughout the country. The statistics of the capacity and availability of these materials are therefore not published. Similarly, no agency in the country undertakes demand surveys of these products.

Attempt was therefore made to collect the requisite information through personal discussions with government officials. An element of respondent bias in this approach is unavoidable, cross-checking of information through discussions with a large number of concerned authorities has helped in reducing the extent of error to the minimum.

1.3 Summary

Individual building materials have been dealt with in separate sections of this report. The main findings of the report are summarised in the next Table.

Table 1.1

Supply Deficit in Specific Building Materials

During 1985-86 to 1990-91

All India Figures

Item	Units	85-86	86-87	87-88	88-89	89-90	90-91
Bricks	Mill. Nos.	25,000	27,000	28,000	29,000	32,000	35,000
Glazed Tiles	Thousand Tonnes	32.5	51.1	73.9	102.6	138.0	181.6
Roofing Tiles	Mill. Nos.	418	598	789	1,249	1,249	1,510
Floor Tiles	Thousand Tonnes	7.5	23.3	25.3	33.5	63.8	91.0

1.4 Status of Glazes

The type of glaze normally used in the ceramics industry is an admixture of silica sand, frits, pigments, feldspar, clay and other chemicals. The proportions vary according to the design of the glaze. The raw materials are mixed in appropriate proportions and are transported to a ball mill where wet mixing and grinding of the glazed material takes place.

The general practice in India is that the large sized units use their own facilities to buy out the frits and then manufacture glazes for their captive consumption. Only such units, who cannot afford the facility of manufacturing glazes themselves, have to depend on out-side sources.

There is only one independent source of supply namely Messrs. Ferro Coatings & Colour, Calcutta, who have a technical collaboration with Ferro Corporation of USA. The capacity of the plant is 4,000 tonnes and production has remaind around 2,000 tonnes per year for the last few years.

The price of frits ranges between Rs.4,000 to Rs.4,500 per tonnes. Prices of colours have not been indicated as these vary widely.

1.5 Firing Capsules

No information could be obtained on this item.
It is possible that this item is referred to under a different nomanclature in India as officials of the Indian Standards Institution /ISI/ were also unaware of it.

2. Building Bricks

2.1 Introduction

In India the bricks industry is primarily in the Small Scale Sector. The hand-moulding process is almost universally followed. This has seriously impeded its capacity to meet the requirements of the construction industry. Moreover, the bricks made by this process are of poor quality. This has lately encouraged the setting up of mechanised brick plants but their introduction too has not been altogether successful. For this reason, the construction activity in the country continues to suffer from an evergrowing shortages in the supply of bricks.

2.2 Demand

According to the findings of a survey carried out by the National Building Organization /NBO/ in 1980, the requirements of bricks for construction activities in 1978-79 was estimated to be 37,500 million. Since then no agency in the country has updated these estimates. Our discussions with officials of NBO and the All India Brick and Tile Federation reveal that in 1982-83 these requirements were of the order of nearly 60,000 million[1].

Official estimates of requirements during the next decade are not available. While NEO is reluctant to hazard any "official guess", an exercise was carried out with the All India Brick and Tile Federation and cross-checked with a few building organizations located in Delhi. Five main segments of construction industry were evaluated, viz.-

a Commercial - modern trend being in favour of multi-storey buildings particularly in large towns;

b Institutional - large emphasis being placed on education and hospital buildings;

c Governmental - the need to build more and more government buildings to cope with expension programmes of governmental activities;

d Housing - this area having attracted the maximum attention of government's welfare programmes to provide houses particularly to middle class and weaker sections of society; and

[1] These estimates relate to domextic requirements, export demand being negligible on account of exhorbitant transportation costs.

e Manufacturing - factory buildings to cope with increasing developmental activities.

This excercise reveals that demand for building bricks is expected to increase to the level of nearly 120,000 million in 1990-91 as tabulated below:

Table 2.1

Estimated Demand for Building Bricks During 1985-86 to 1990-91

/Million Numbers/

Year	All-India
1985-86	78,000
1986-87	85,000
1987-88	92,000
1988-89	100,000
1989-90	110,000
1990-91	120,000

2.3 Availability

All-India

Official estimates of the supply of bricks are not available. The NBO's latest statistics are out-dated and bear no relationship with their earlier estimates. The main reason for this lacunae is because of the fact that the brick-making industry is in the small scale and sometimes even in the cottage sectors. Capacity and production data are not regularly reported by these sectors to any agency in the country.

Projections of future availability of building bricks in the country, as summarised in the following table, indicate that the ply of these bricks is expected to increase from t present level of about 40,000 million to nearly 000 in 1990-91.

Table 2.2

Estimated Total Availability of Building Bricks During 1985-86 to 1990-91

/Million Numbers/

Year	All-India		
	Mechanized Plants	Hand Moulded	Total
1985-86	40	53,000	53,040
1986-87	40	58,000	58,040
1987-88	45	64,000	64,045
1988-89	45	71,000	71,045
1989-90	50	78,000	78,050
1990-91	60	85,000	35,060

Source: Based on Table 2.5

The brick-making industry comprises of two sectors: State-owned mechanized brick plants and private sector hand-made brick kilns.

1 Mechanized Brick Plants

There are presently, nine mechanized brick plants, most of them having been set-up in the country by State Governments. While the installed capacity of these plants is nearly 175 million bricks per annum, their maximum production so far has been 70 million; even at present, four of these plants are lying closed. There are two reasons which have contributed to the poor capacity utilization of these plants: lack of quick commercial decision making due to beaurocratic administrative set-up, and relatively high cost of production thereby making these bricks uncompetitive with those made by the non-mechanized, privately owned kilns. The National Buildings Construction Corporation /NBCC/ plant at Delhi has been sold to a private party. Even the bricks produced at these plants have been sold mainly to government departments because private parties are unwilling to pay higher prices.

Table 2.3

Estimated Capacity and Production of Mechanized Brick Plants

/Million Numbers/

Unit	Installed Capacity	1978	1979	1980	1981	1982
NBCC Mechanized Brick, Plant, Delhi	40.00	14.0	15.0	16.0	-	-
Mechanized Brick Plant, Calcutta	33.00	10.0	10.0	21.0	-	-
Housing Board Brick Unit, Madras	19.95	10.0	10.0	12.0	13.0	13.0
Tamil Nadu Ceramics Limited, Madras	19.80	8.0	8.0	8.0	10.0	12.0
KS Kasimaria Ceramics Pvt. Ltd., Madras	15.00	6.0	7.5	7.0	7.0	8.0
Housing Board Brick Unit, Madras	16.25	2.0	4.0	-	-	-
Mechanized Brick Plant, Paonta Sahib, /HP/	10.00	1.9	2.0	2.1	2.1	1.6
Mechanised Brick Plant, Assam	10.00	0.5	1.0	1.0	-	-
Mechanized Brick Plant, Srinager	10.00	1.0	1.3	1.5	1.5	2.0
Total	174.00	53.4	58.8	68.6	23.6	36.6

Unless the present administrative set-up of these plants is changed it is less than likely that their performance will improve in the near future. Future production from these plants has therefore been estimated to be no more than 60 million bricks per annum till 1990-91.

2 Hand-made Brick Kilns

The hand-made building bricks industry is in the unorganized sector and very little data is available about this industry. The information given in this report is based on discussions with the All India Brick and Tile Federation and the National Building Organization.

Production of building bricks out of red clay is centred around big cities and district headquarters and is seasonal in character. Almost 99 percent of the bricks produced in the country are in the hands of small scale operators, who employ little or no machinery and the entire process of manufacture is done by manual labour. It has been estimated that about 40,000 million bricks are produced in the country by about 15,700 kilns spread all over the country. During the past five years, production of these units has increased from 22,000 million in 1978-79 to 40,000 million in 1982, i.e. by about 16 percent per annum.

Table 2.4

Estimated Production of Hand-Moulded Bricks During 1981-83

Region	Number of kilns 1982-83	Estimated production /Million Numbers/ 1981-82	1982-83
Punjab, Haryana, Chandigarth, HP and J&K	3,000	9,300	10,800
UP, Delhi and Rajasthan	6,000	16,300	19,00
West Bengal, Bihar and North-Eastern States	2,000	3,400	4,000
Tamil Nadu	500	800	1,000
Orissa	200	350	400
Karnataka, Kerala	400	700	800
Gujarat and Maharashtra	2,500	2,130	2,500
Andhra Pradesh	400	700	800
Others	700	620	700
Total	15,700	34,300	40,000

The major brick producing states in the country are Uttar Pradesh, Punjab, Haryana and Delhi, where the required raw materials for producing good quality bricks at economical cost are easily available. An average unit of production in these states is capable of producing about 3 million bricks per annum, employing about labourers, with an investment of Rs. 200 to Rs. 300 thousand.

The agencies cited above, are of the opinion that these kilns are capable of increasing their production to the extent of 85,000 million provided supply of essential raw materials, particularly coal, is ensured. Estimates of availability over the next few years are given below:

Table 2.3

Estimated Availability of Hand-Made Bricks During 1985-86 to 1990-91

/Million Numbers/

Year	Estimated Production All-India
1985-86	53,000
1986-87	58,000
1987-88	64,000
1988-98	71,000
1989-90	78,000
1990-91	85,000

Source: Based on Discussions with All-India Brick And Tiles Federation

2.4 Market Potential

A gap between demand and availability for building bricks in India has been in existence for the past several years. This has contributed to a continued increase in prices of bricks and has sometimes even resulted in a slowing down of construction activity. This shortage is due mainly to the inadequate availability of coal for the bricks industry and unsatisfactory progress of the mechanised brick plants. As shown in the following table, the gap between demand and supply is expected to increase from the colossal figure of 25,000 million bricks in 198-86 to 32,000 millions in 1990-91.

Table 2.6

Estimated Demand-Supply Gap in Building Bricks During 1985-86 to 1990-91

	All-India		
Year	Demand	Supply	Gap
1985-86	78,000	53,000	24,960
1986-87	85,000	58,040	26,960
1987-88	92,000	64,045	27,955
1988-89	100,000	71,045	28,955
1989-90	110,000	78,050	31,950
1990-91	120,000	85,060	34,940

2.5 Prices

The prices of bricks have been on the increase. During the past five years the prices of both mechanised and manual bricks have gone up by about 50 percent. The following table illustrates periodic changes in these prices in Delhi. It will be observed that the prices of mechanised bricks are substantially higher than those of manually made bricks due to higher labour cost of both skilled and unskilled workers and higher coal prices. Though prices vary from state to state, depending on local costs of labour and raw materials, the difference is not very large.

Table 2.7.

Market Prices of Mechanised and Manual Bricks in Delhi

/Rs. per Thousand Bricks/

	Effective Dates			
Mechanized Bricks	1 Jan 1978	1 Mar 1979	1 Aug 1979	1 Feb 1980
Special Quality	245	280	350	370
"A" Quality	200	230	290	320
"B" Quality	145	145	180	210
Manual Bricks	29 May 1979	4 Aug 1980	5 Jan 1981	12 May 1982
"A" Quality	168	186	200	240
"B" Quality	157	174	186	220
"C" Quality	135	150	164	204

Source: NBCC Mechanized Brick Plant, Delhi

3. Glazed Tiles

3.1 Introduction

Glazed tiles are gaining importance in the building industry. In addition to their aesthetic appearance in bath-rooms, this material is gradually finding application in offices, hotels, restaurants, laboratories and apartment buildings. In some cases, these tiles are rapidly replacing marble mosaic tiles /terrazzo tiles/ because they provide a cleaner, brighter and more pleasing surface at about the same cost including final installation.

3.2 Demand

3.2.1 Total Demand

Demand for glazed tiles comprises both domestic requirements and exports to overseas markets. As shown in following table, these requirements are expected to increase from the present level of nearly 52,000 tonnes in 1980-81 to 126,500 tonnes in 1985-86 and approximately 315,000 tonnes in 1990-91.

Table 3.1

Estimated Total Demand for Glazed Tiles

Year	Domestic Demand	Exports	Total
1980-81	48.3	3.6	51.9
1984-85	98.0	7.5	105.5
1985-86	117.6	8.9	126.5
1986-87	141.1	10.7	151.8
1987-88	169.3	12.9	182.2
1988-89	203.2	15.4	218.6
1989-90	243.8	18.5	261.5
1990-91	292.6	22.0	314.6

Source: Based on Tables 3.2 and 3.4

3.2.2 Domestic Demand

All-India

Ceramic glazed tiles manufactured in India are exclusively used for wall surface - mainly in bathrooms and certain specialized applications as, e.g., in chemical laboratories and clean rooms. So far none of the Indian units has commercially produced or marketed unglazed tiles for use as flooring material.

The past two decades /1961-81/ have witnessed spectacular growth in the demand for these tiles - nearly 13.4 per cent p.a. /Annex B/. During the past six years /1975-76 to 1981-82/ domestic demand in India has gone up 14.5 percent p.a. viz, from 24,000 tonnes in 1975-76 to 54,000 tonnes in 1981-82.

Keeping in view the pace of construction activity in the country and changes in people's tastes in favour of more and more utility materials, the Planning Commission have assessed the demand for glazed tiles at 98,000 tonnes per annum by 1984-85, including 22 percent annual growth during the 1981-84 period. Our discussions with leading manufacturing units and building organisations indicate that demand during the next 5-6 years is likely to grow at 20 percent per annum. These assumptions have been quantified in the following table. It will be noted that domestic demand for glazed tiles is likely to increase from the present /1981-82/ level of 54,000 tonnes to 118,000 tonnes in 1985-86 and nearly 290,000 tonnes in 1990-91.

Table 3.2

Estimated Domestic Demand for Glazed Tiles

Year	Estimated Demand /Thousand Tonnes/
1979-80	42.6
1980-81	48.3
1981-82	54.0
1982-83	65.9
1983-84	80.4
1984-85	98.0
1985-86	117.6
1986-87	141.1
1987-88	169.3
1988-89	203.2
1989-90	243.8
1990-91	292.6

Source: Based on Annex B

As shown in Annexure C the regular overseas markets for Indian glazed tiles include Bangladesh, Bahrein, Kuwait, Kenya, Nepal, Malaysia, Seychelles, Oman, Oatar, South Yemen, Saudi Arabia, UAE, and of late, even USSR. These together account for 60 to 65 percent of India's total exports.

Construction activity in India's principal overseas markets is at its zenith. So is the case with their demand for Indian glazed tiles. Our discussions with major exporters and the Chemical and Allied Products Export Promotion Council /CHEMPEXIL/ reveal that Indian exports of tiles are expected to grow 20 percent per annum during the next decade. Accordingly, based on current prices, these exports are estimated at 22,000 tonnes in 1990-91.

Table 3.4

Projections of Indian Exports of Glazed Tiles

/Thousand Tonnes/

Year	Estimated Exports	Year	Estimated Exports
1981-82	4.30	1986-87	10.70
1982-83	5.20	1987-88	12.90
1983-84	6.20	1988-89	15.40
1984-85	7.50	1989-90	18.50
1985-86	8.90	1990-91	22.00

3.2.3 Exports

Glazed tiles from India are exported to nearly 40 countries. During the past 6 years these exports have been fluctuating. For instance, during the first three years /1979-80 to 1981-82/ exports quadrupled; in the following two years exports declined but in 1984-85 exports picked up once again. Over the past six years, the average annual growth has been of the order of 25 percent. Annaul export performance is tabulated below:

Table 3.3

Indian Exports of Glazed Tiles During 1979-80 to 1984-85

/Tonnes/

Year	Exports
1979-80	661
1980-81	11,327
1981-82	27,732
1982-83	5,421
1983-84	1,623
1984-85	3,591

Source: Based on Annexure C

3.3 Availability

3.3.1 Sturcture of Glazed Tile Industry

All-India

There are five units in the organised sector engaged in the manufacture of glazed tiles in the country. In addition, there are nearly 50 units in the small scale sector spread throughout the country and producing sub-standard tiles. Their names and the share of the market are given below:

Name of Unit	%age share of market
1. H&R Johnson /India/ Ltd., Bombay	60 %
2. Bombay Potteries & Tiles Ltd., Bombay	8 %
3. Eastern Ceramics Ltd., Bombay	7 %
4. Parshuram Pottery Works Co. Ltd., Wankaner /Gujarat/	7 %
5. Somany Pilkington's Ltd., Rohtak /Haryana/	5 %
6. Small Scale Sector Units	13 %
Total	100 %

It will be noted that the industry is localized in the states of Maharashtra, Haryana and Gujarat. One more unit in Rajasthan is likely to come on stream with an installed capacity of about 12,000 tonnes per annum. Moreover, as stated below, four units are also likely to be set up in the state of Andhra Pradesh.

It is significant to note that the manufacture of glazed tiles upto size 10 cm x 10 cm is now reserved for exclusive development in the small scale sector.

3.3.2 Capacity and Production

All-India

The installed capacity of the existing five units in the organized sector has gone up from 45,000 tonnes in 1972 to 59,900 tonnes in 1981. Similarly, production of tiles by these units has increased from 25,000 tonnes to 56,980 tonnes during the same period. Thus, while during the past nine years capacity went up by 3.2 percent per annum, production registered a sharp increase of 12 percent per annum. Likewise, capacity utilisation has gone up from 55 to 95 percent during the period. Annual trends in capacity and production are tabulated in Annexure B.

An additional capacity of 119,700 tonnes has been approved by the government under various letters of intent/industrial licences. Out of this, a capacity of 32,000 tonnes is expected to materialize in 1984-85, and additional 48,000 tonnes by 1990-91. This, in 1990-91 the installed capacity of the organized sector will be raised to 140,000 tonnes. Assuming capacity utilization of 95 percent, production of glazed tiles is expected to be of the order of nearly 133,000 tonnes in 1990-91. Annual projections of capacity and production are given in the following table:

Table 3.5

Estimated Capacity and Production of Glazed Tiles During 1981 to 1990

/Thousand Tonnes/

Year	Estimated Capacity	Estimated Production	Year	Estimated Capacity	Estimated Production
1981-82	59.90	56.98	1986-87	106.00	100.70
1982-83	69.00	65.00	1987-88	114.00	108.30
1983-84	80.00	76.00	1988-89	122.00	116.00
1984-85	92.00	87.40	1989-90	130.00	123.50
1985-86	99.00	94.05	1990-91	140.00	133.00

3.4 Market Potential

The gap between estimated demand and supply of glazed tiles represents the market potential for now entrants. As shown in the following table, this gap works out to around 18,000 tonnes in 1984-85 which is expected to reach the staggering level of approximately 180,000 tonnes in 1990-91 unless additional capacities are set up during the intervening period to bridge this gap.

Table 3.6

Estimated Demand-Supply Gap in Glazed Tiles.

All-India

Year	Demand	Supply	Gap
1984-85	105.5	87.4	- 18.1
1985-86	126.5	94.0	- 32.5
1986-87	151.8	100.7	- 51.1
1987-88	182.2	108.3	- 73.9
1988-89	218.6	116.0	- 102.6
1989-90	261.5	123.5	- 138.0
1990-91	314.6	133.0	- 181.6

Source: Based on Tables 3.1 and 3.5 and sub-section 3.3.2

3.5 Prices

The prices of ceramic glazed tiles depend on the size, quality and colour of these tiles. During the past five years the prices of glazed tiles have gone up by about 60 percent.

4. Roofing Tiles

4.1 Introduction

Mangalore pattern clay roofing tiles were first developed in Mangalore in 1865 by German Missionaries. These tiles are of the interlocking type and are most popular in the coastal states, mainly amongst the poorer people to build houses and sheds. An essential feature of these tiles is that the overlap of the upper row exactly fits the grooves of the lower row. Moreover, for locations subject to heavy rains, provision is made for wiring the tiles to the battens to secure them against any heavy gale or storm. The weight of 100 sq. ft. of roofing tiles is approximately 700 lbs. /or 317.5 kg/.

These tiles are considerably cheaper than corrugated iron sheets or patent roofing. Besides being more durable, they are more easily laid. When properly fitted, they make a perfectly wind and water-tight roof. They are practically indestructible by climatic influences and their thermal insulating properties far surpass those of other material in a similar price range. Other advantages of these tiles include:

- resistance to heat,
- high breaking strength, and
- perfect fit and elegant appearance.

4.2 Types of Roofing Tiles

These tiles are produced in a variety of forms to suit different requirements and pockets. These types are:

a Fort roofings
b Truss roofings
c Basel mission roofings
d Taylor tiles
e Ridge tiles
f Taylor ridges
g Ceiling tiles
h Flooring tiles
i Terrace slabs
j Hourdis

Details of the above types of tils are given in Annexure D.

4.3 Demand

4.3.1 Total Demand

The demand for Mangalore pattern roofing tiles is expected to increase from the present level of nearly 1,900 million numbers in 1980-81 to 2,500 million in 1985-86 and 4,010 million in 1990-91.

Table 4.1

Estimated Total Demand for Roofing Tiles

/Million Numbers/

Year	Domestic Demand	Exports	Total
1984-85	2,260.0	8.0	2,268.0
1985-86	2,490.0	8.3	2,498.3
1986-87	2,740.0	8.5	2,748.5
1987-88	3,010.0	8.7	3,018.7
1988-89	3,310.0	9.0	3,319.0
1989-90	3,640.0	9.5	3,649.5
1990-91	4,000.0	10.5	4,010.5

4.3.2 Domestic Demand

All-India

Demand estimates of roofing tiles are not documented. Popularity of thes tiles, particularly in rural areas, is growing every year. At present the consumption of these tiles is confined mainly to the state of Kerala whereas small quantities are also being used in Karnataka and Andhra Pradesh. It is estimated that future demand for these tiles will grow at 10 percent per annum as against 28.5 percent annual growth. Accordingly, demand for these tiles is expected to reach the level of 4,000 million in 1990-91.

Table 4.2

Estimated Domestic Demand for Roofing Tiles During 1983 to 1990

/Million Numbers/

Year	Estimated Demand	Year	Estimated Demand
1983-84	2,060	1987-88	3,010
1984-85	2,260	1988-89	3,310
1985-86	2,490	1989-90	3,640
1986-87	2,740	1990-91	4,000

4.3.3 Exports

Roofing tiles are exported to surrounding countries of South East Asia and Middle East. Export data for the past six years is tabulated in Annexure F. It will be noted that in view of the mounting transportation costs and exports of these tiles have not exceeded 8 million in numbers. Moreover, since the use of these tiles in surrounding countries is preferred by the people of Indian origin only, exports in future are unlikely to increase substantially. Nearly 90 percent of these tiles are exported to Kuwait and Sri Lanka where Indians from Southern coastal states have settled. Not more than 10 million numbers of these tiles are expected to be exported in any year during the next decade.

4.4 Availability

All-India

Facilities for the manufacture of these tiles are concentrated in the State of Kerala which alone has about 500 factories in the organized sector manufacturing these tiles most of whom conform to ISI Standards. These are in addition to a large number of small scale units which bring out sub-standard roofing tiles. The state of Karnataka has a limited number of factories. In Andhra Pradesh, the units are mostly in the small scale sector. Following are the reasons for the concentration of these factories in Kerala State:

- availability of suitable clay, plastic and lean clay;
- easy availability of firewood and fuel;
- river facilities; and
- availability of local artisans who enjoy inherited skill

Production of these tiles during the past four years has almost doubled. In 1982 total production was of the order of 1,871 million as against 885 million numbers in 1980, registering 28.5 percent annual growth.

The Western India Tile Manufacturers' Association is of the view that existing manufacturing units are equipped with the necessary facilities to turn out nearly 2,500 million numbers of these tiles. Thus, unless new large scale units make their entry, future production of these tiles in 1990 may be assumed to centre around 2,500 million numbers. Annual availability in the next decade is shown in Table 4.4.

Table 4.3

Production of Roofing Tiles During 1980 to 1983

/Million Numbers/

State	1980	1981	1983	1983
Kerala	825	1,150	1,400	1,750
- Organized sector	600	850	1,000	1,250
- Unorganized sector	225	300	400	500
Karnataka	40	55	67	85
- Organized sector	30	40	50	65
- Unorganized sector	10	15	17	20
Andhra Pradesh	20	25	30	36
- Organized sector	-	-	-	-
- Unorganized sector	20	25	30	36
Total	885	1,230	1,497	1,871

Table 4.4

Estimated Availability of Roofing Tiles During 1983 to 1990

/Million Numbers/

Year	Estimated Production	Year	Estimated Production
1983-84	1,940	1987-88	2,230
1984-85	2,000	1988-89	2,300
1985-86	2,080	1989-90	2,400
1986-87	2,150	1990-91	2,500

4.5 Market Potential

The gap in demand over estimated availability of roofing tiles in the country is expected to grow from nearly 420 million numbers in 1985-86 to 1,500 million in 1990-91.

Table 4.5

Estimated Demand-Supply Gap in Roofing Tiles

All-India

/Million Numbers/

Year	Demand	Supply	Gap
1984-85	2,268	2,000	- 269
1985-86	2,498	2,080	- 418
1986-87	2,748	2,150	- 598
1987-88	3,019	2,230	- 789
1988-89	3,319	2,300	- 1,019
1989-90	3,649	2,400	- 1,249
1990-91	4,010	2,500	- 1,510

5. Floor Tiles

5.1 Introduction

Floor tiles are used in almost every building, particularly in urban areas. There are three main categories of these tiles:

a National Stone Tiles: These include

- Cuddapah Slabs
- Tandur Slabs
- Lime Stone
- Marble and Marble Silt Type

b Cement-based Tiles: These include

- Cast in Situ
- Mosaic Tiles
- Gray Tiles

c Ceramic tiles which are made with ordinary clay presently in vogue in Kerala and Tamil Nadu.

This section deals with the second category, viz., cement-based tiles used as floor and wall tiles.

5.2 Demand

5.2.1 Total Demand

Total demand for cement /floor/ tiles is expected to increase to the level of 230,000 tonnes in 198586 and 450,000 tonnes in 1990-91.

Table 5.1

Estimated Total Demand for Cement /Floor/ Tiles During 1984-85 to 1990-91

/Thousand Tonnes/

All-India

Year	Domestic Demand	Exports	Total
1984-85	210	2.2	212.2
1985-86	230	2.2	232.2
1986-87	270	2.5	270.5
1987-88	295	2.5	297.5
1988-89	340	2.7	342.7
1989-90	390	2.8	392.8
1990-91	450	3.0	453.0

5.2.2 Domestic Demand

All-India

On an average cement tiles comprise nearly 25 percent of the total plinth area, mostly in urban areas. 60 percent of the plinth area is covered by stone tiles, 10 percent by PVC tiles and the remaining 5 percent by other types of tiles.

Official statistics of the demand for floor tiles or the plinth area are not published in the country. However, our discussions with the All India Tile Manufacturers' Association, Bombay and the largest manufacturer-exporter of these tiles /NITCO, Delhi/ in the country have revealed that at present consumption of cement tiles is approximately 192,000 tonnes and that annual growth in these requirements during the past five years has varied between 7 to 10 percent. Based on these discussions, annual demand data of the cement tiles during 1980 to 1984 are shown in the following table.

Table 5.2

Estimated Domestic Requirements of Cement /Floor tiles/

/Thousand Tonnes/

Year	Estimated Domestic Demand
1980	130
1981	140
1982	150
1983	170
1984	192

Past consumption of these tiles could not register high growth mainly due to the constraints in the availability of cement in the country. This situation is likely to improve dring the Seventh Plan Period. Accordingly, the Tile Manufacturers' Association is hopeful that a 10 to 15 percent annual growth will be registered during the next decade. This growth in demand is most likely to materialize as construction activity gains momentum in the country, consequent on larger allocation of funds for the purpose. Accordingly, demand for these tiles is expected to reach the level of 450,000 tonnes in 1990-91.

Table 5.3

Estimated Domestic Demand for Cement /Floor/ Tiles During 1984-85 to 1990-91

/Thousand Tonnes/

Year	Estimated Domestic Demand
1984-85	210
1985-86	230
1986-87	270
1987-88	295
1988-89	340
1989-90	390
1990-91	450

5.2.3 Exports

Exports of cement tiles are insignificant and are of recent origin only. As shown in the following table, these tiles are being exported to near-by countries. This is due to the heavy freight costs. Another reason which is responsible for discouraging large-scale exports is the attempt of Middle Eastern Countries to utilize their local clay for this purpose. According to the views expressed by the larges exporter of these tiles, future exports are unlikely to exceed 3,000 tonnes in any year.

Table 5.4

Indian Exports of Cement /Floor/ Tiles

/Tonnes/

Destination	1980-81	1981-82	1982-83	1983-84
Bahrein	253	255	-	26
Belgium	-	-	-	50
Iraq	-	79	-	292
Qatar	780	-	-	15
Ethiopia	-	66	30	-
Kuwait	-	36	-	-
Oman	90	80	65	-
Saudi Arabia	238	1,407	-	-
Sri Lanka	-	8	3	-
UAE	580	118	-	-
Yemen Arab Rep.	-	59	-	-
USSR	48	-	-	-

5.3 Availability

All-India

There are about 2,000 units in the country manufacturing cement /floor/ tiles. The industry is concentrated in the following cities:

Location	Number of Units
Bombay	100
Ahmedabad	100
Bangalore	60
Morwi /Gujarat/	50
Hyderabad	40
Madras	20
Delhi	10

The average capacity of these units is nearly 35,000 tiles per annum, each tile weighing about 3.2 kg., in the size range of 25 cm x 25 cm. Since no industrial licence is required for setting up these units in the Small Scale Sector, information about their expansion plans or setting up of new units is not documented by any agency. The growth in production of these units in the next decade will be approximately 7 to 10 percent as the units are already operating at near full capacity utilization. Following table provides an idea of the estimated production of cement tiles in the next few years.

Table 5.5

Estimated Availability of Cement /Floor/ Tiles During 1984-85 to 1990-91

/Thousand Tonnes/

Year	Estimated Production All-India
1984-85	210.0
1985-86	224.7
1986-87	247.2
1987-88	272.0
1988-89	299.2
1989-90	329.1
1990-91	362.0

5.4 Market Potential

All-India

The gap between demand and supply of cement tiles expected to increase from about 7,500 tonnes in 1985-86 to nearly 91,000 tonnes in 1990-91.

Table 5.6

Estimated Demand-Supply Gap in Cement /Floor/ Tiles During 1985-86 to 1990-91

/Thousand Tiles/

Year	All-India		
	Demand	Supply	Gap
1985-86	232.2	224.7	- 7.5
1986-87	270.5	247.2	- 23.3
1987-88	297.5	272.0	- 25.5
1988-89	342.7	299.2	- 33.5
1989-90	392.8	329.0	- 63.8
1990-91	453.0	362.0	- 91.0

Annexure A

List of Parties and Agencies Contacted

New Delhi

1 All India Brick and Tile Federation, New Delhi

2 Chemicals and Allied Products Export Promotion Council, New Delhi

3 Central Public Works Department, New Delhi

4 Central Road Research Institute, Okhla, New Delhi

5 Development Commissioner, Small Scale Industries, New Delhi

6 Directorate General of Technical Development, New Delhi

7 Housing and Urban Development Corporation, New Delhi

8 India Investment Centre, New Delhi

9 Indian Standards Institution, New Delhi

10 National Building Organisation, New Delhi

11 NBCC Mechanized Brick Plant, New Delhi

12 NITCO Tiles, Delhi

13 Town and Country Planning Organization, New Delhi

14 Punjab Potteries Ltd., Palam, New Delhi

Bombay

15 Indian Ceramic Society

Annexure B

Capacity and Production of Glazed Tiles in India during 1961 to 1981

/Thousand Tonnes/

Year	Installed Capacity	Production
1961	7.98	4.68
1962	7.98	5.52
1963	7.98	5.96
1964	7.98	6.67
1965	7.98	6.59
1966	7.98	8.13
1967	9.04	11.98
1968	8.24	14.00
1969	8.24	17.66
1970	8.24	16.64
1971	21.12	20.70
1972	45.00	25.00
1973	45.00	26.70
1974	45.00	29.10
1975	45.00	24.49
1976	45.82	36.75
1977	45.82	42.09
1978	N.A.	41.78
1979	N.A.	44.17
1980	N.A.	51.90
1981	59.90	56.98

Sources: 1 "Guidelines for Industries", Ministry of Industry, New Delhi

2 Indian Ceramic Society, Bombay

Annexure C

Indian Exports of Glazed Tiles by Destination

Destination	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Australia	-	-	-	63	-	-
Bahrein Island	81	578	381	242	27	18
Ethiopia	-	76	4	92	8	-
Kenya	33	71	705	219	80	471
Kuwait	53	2,168	723	88	43	--
Mali	-	-	-	1	-	--
Nepal	14	94	24	261	43	228
Nigeria	-	-	4	273	-	80
Oman	-	1,668	3,207	961	464	392
Qatar	53	935	2,266	48	10	-
Saudi Arabia	-	467	6,824	1,112	85	25
Seychelles	-	12	10	7	12	10
Singapore	-	-	141	6	18	-
Somalia	-	-	-	6	-	-
Sri Lanka	-	-	-	50	-	34
Tanzania Rep.	44	61	-	50	320	-
UAE	37	4,802	11,330	1,169	154	697
USSR	-	-	255	96	136	339
Yemen Arab Rep.	35	136	220	677	61	8
Malaysia	-	25	75	-	136	13
Iraq	-	-	12	-	56	60
Malawi	62	-	-	-	-	-
Bangladesh	26	94	54	-	13	54
Mauritius	2	-	-	-	-	-
USA	-	-	167	-	-	-
Uganda	-	-	33	-	-	-
Muscat	68	-	-	-	-	-
Yemen P. Rep.	51	82	38	-	-	-

Destination	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Zambia	101	-	-	-	-	-
France	-	-	149	-	-	15
Iran	-	-	992	-	-	-
Japan	-	-	21	-	-	-
Philippines	-	-	10	-	-	-
Sudan	-	-	86	-	-	-
Thailand	-	5	1	-	-	-
Afghanistan	-	21	-	-	-	9
Italy	-	-	-	-	-	53
New Zealand	-	-	-	-	-	30
Netherlands	-	1	-	-	-	22
Pakistan	-	27	-	-	-	-
Total	661	11,327	27,732	5,421	1,623	3,591

Annexure D

Types of Roofing Tiles

a **Fort Roofings:** These are meant for buildings with double interlocking. They can withstand every test for strength, reliability and weather worthiness. They are designed in such a manner that there is no possibility of leakage. Their average size is 417 x 261 mm. Their breaking strength is 120 kg in a wet state. They cover an area of 100 sq. metres requiring 1,300 numbers. One thousand of these tiles occupy a bulk volume of 3.5 cubic metres.

b **Truss Roofings:** 120 numbers are required for 100 sq. ft. /9.29 sq. metres/. Their breaking strength is 104 kg. One thousand of these tiles weigh 2.79 tonnes. Their size is 417 x 255 mm. These tiles may be laid straight or breaking joints. Their water absorption capacity is 18.5 percent. One thousand of these tiles have a bulk volume of 3.4 cubic metres.

c **Basel Mission Roofings:** To cover 100 sq. ft. on a reeper spacing of 124", approximately 130-140 tiles are required. Their breaking strength is 108 kg. One thousand of these tiles weigh 2,54 tonnes in wet state. Their size is 414 x 239 mm and water absorption 19 percent. One thousand of these tiles will have a bulk volume of 3 cubic metres. These tiles can be used on reeper spacing from 124" to 134". They are suitable for laying both straight and breaking joints.

d **Taylor Tiles:** These are smaller tiles with an overall length of 114". They are laid on a reeper spacing of 9". 2,240 numbers of these tiles are required for 100 sq. metres. One thousand of them weigh about 1.4 tonnes. They are laid on concrate sloping roofs. They have better appearance and better insulation.

e **Ridge Tiles:** 16" long tiles, as they are, weigh 3.4 kg. each. Each tile covers 2 flat tiles on each side of the ridge. 280 numbers of these tiles are required for 100 sq. metres of area.

f **Taylor Ridges:** These are used along with Taylor tiles and are semi-circular in shape. 184" in length, 260 ridges are required for 100 running metres. Their bulk volume is 4 cubic metres.

g **Ceiling Tiles:** Along with Mangalore tiles over them, ceiling tiles form a cheap, effective and simple double roofing system with air space between them. They cover the same area as roofing tiles and also create a pleasant temperature in the room.

h Flooring Tiles: These are used in houses, godowns and factories. These are supplied in sizes of 9" x 9" and 6" x 6". Straight or diagonal halves to suit both the sizes are also supplied.

i Terrace Slabs: These are made from tarracotta insulting materials, and are in the size of 10" x 5" x 4". 300 numbers of these tiles cover 100 sq. ft. They weigh one kg. each and are used as inexpensive pavement and flooring for bar becues, porches, barns and garages.

j Hourdis: These are long thin-walled hollow bricks with strengthening intermediate ribs. These slabs are adopted for flat roofs as they furnish a water right strength. These slabs can bear a load of 226.8 kg. per sq. f. uniformly distributed. Their other advantages are: resistance to heat and light in weight; strong and durable. These are made in sizes of 1"x9"x3", 2"x9"x3" and 24"x9"x3".

Annexure E

Indian Exports of Roofing Tiles by Destination

/Thousand Numbers/

Destination	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85
Bahrein Islands	-	30	-	-	-	50
Iraq	-	-	-	-	-	11
Kuwait	718	919	3,189	589	471	3,566
Maldiv Island	-	8	-	1	-	60
Nepal	314	231	-	40	446	23
Oman	-	-	212	20	30	56
Qatar	34	599	534	219	158	78
Saudi Arabia	-	160	2,496	130	-	169
Sri Lanka	-	-	-	2,514	1,978	3,380
UAE	641	202	1,511	541	363	346
Yemen Arab Rep.	-	-	-	36	-	100
Bangladesh	-	-	35	120	20	-
Italy	190	24	113	-	-	-
Philippines	-	-	69	-	-	-
Nigeria	-	-	-	30	-	-
Muscat	195	-	-	-	-	-
Egypt	136	-	-	-	-	-
Zambia	170	-	-	-	-	-
Total	2,398	2,173	8174	4,240	3,624	7,844

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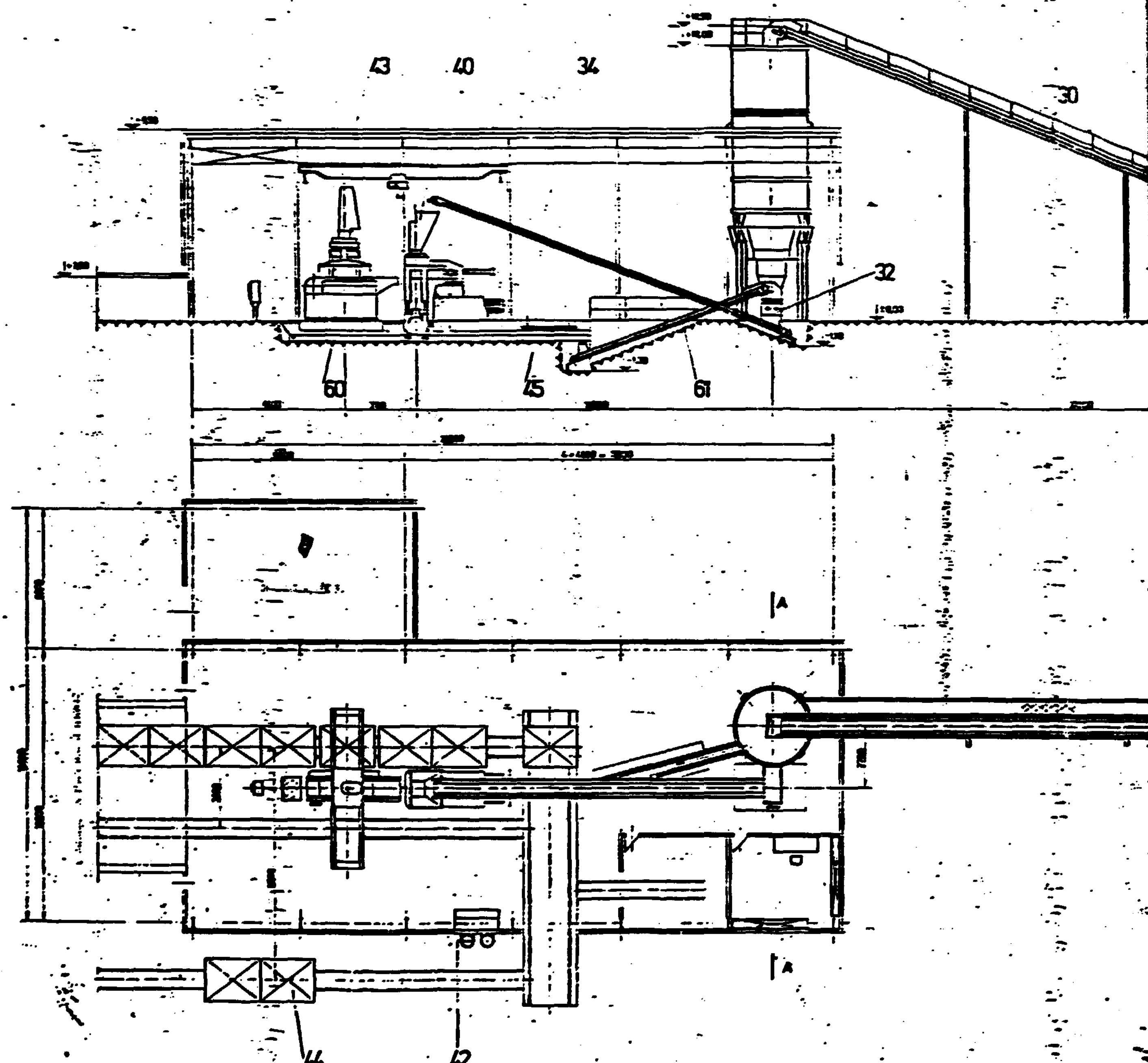

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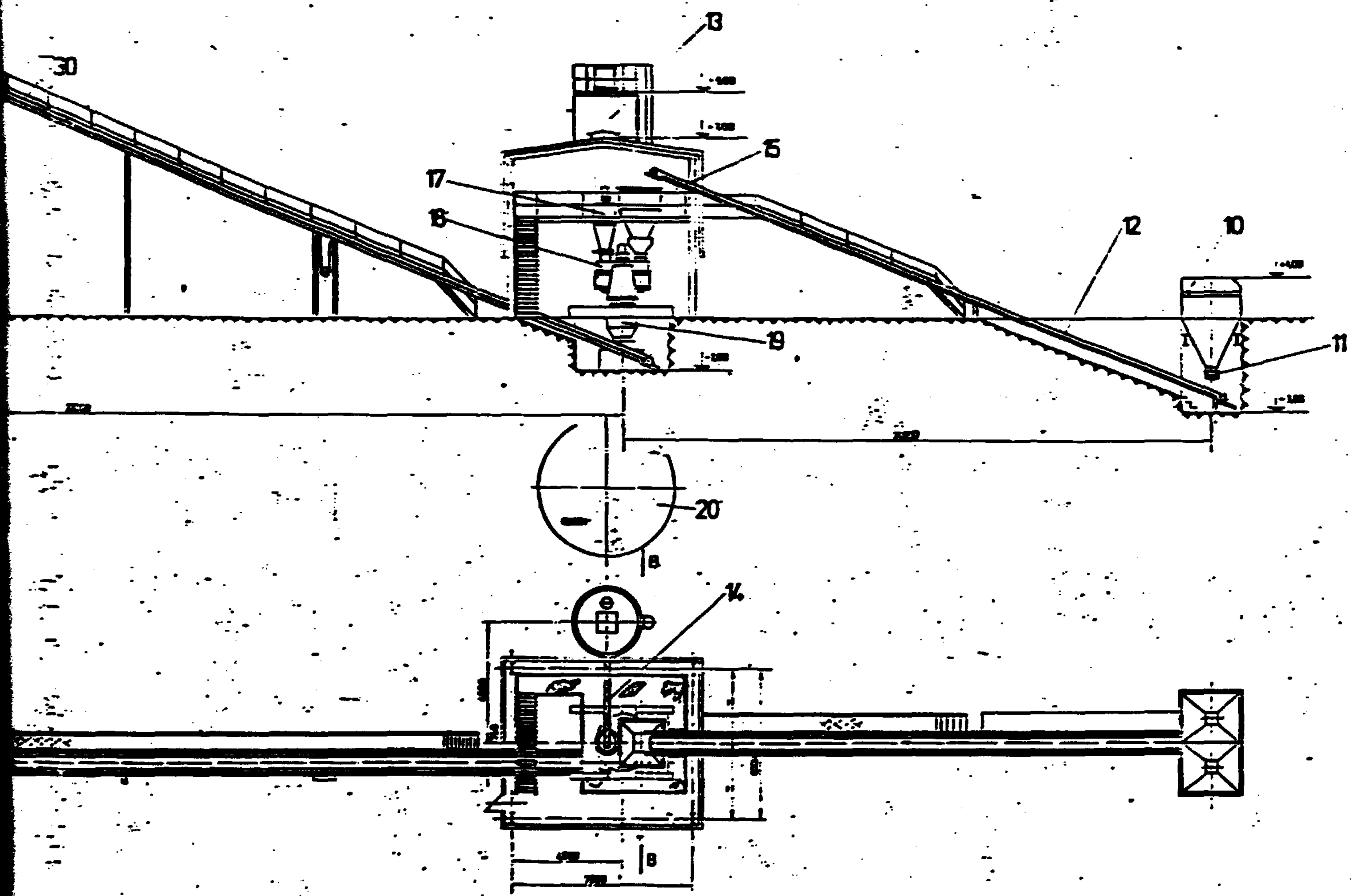

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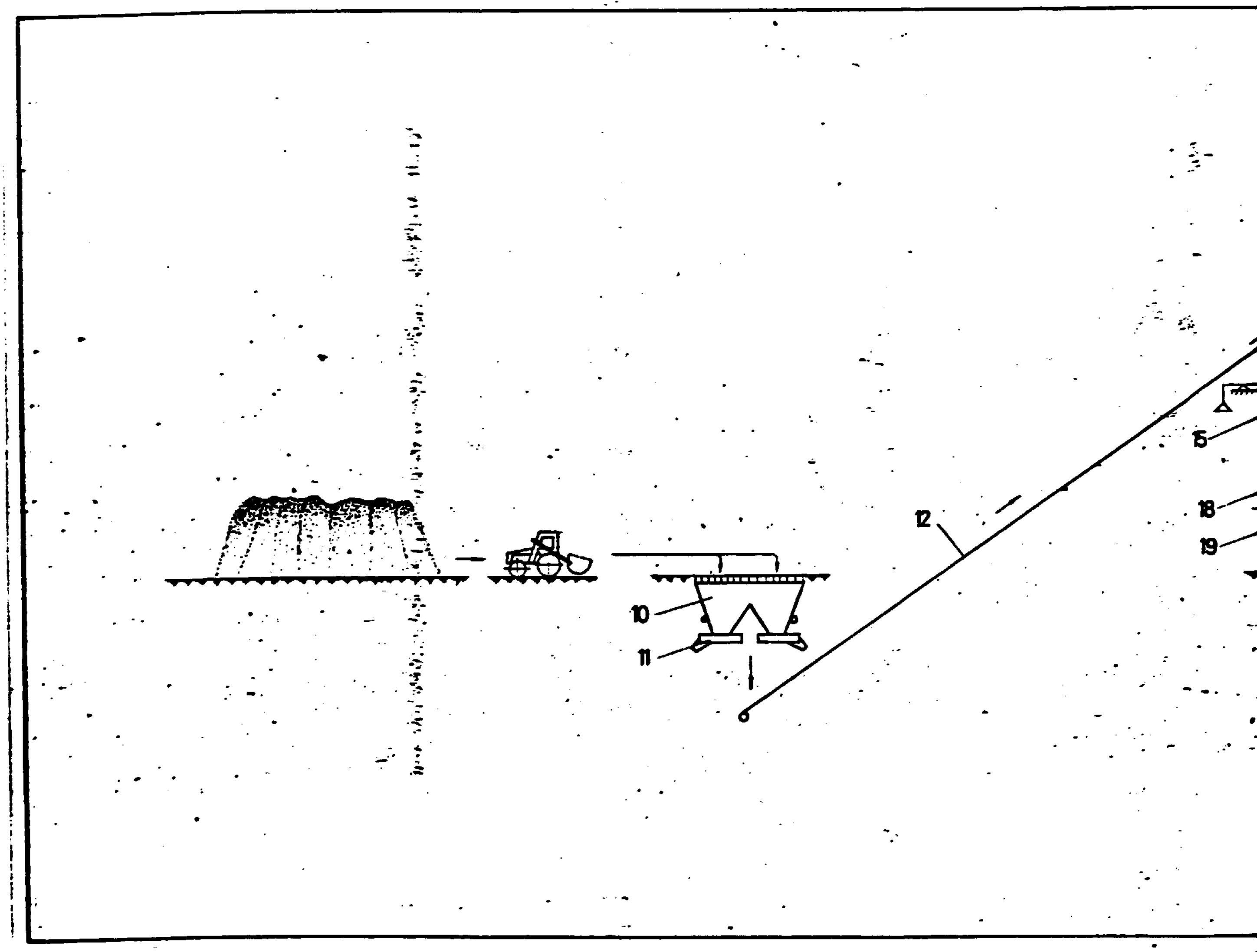

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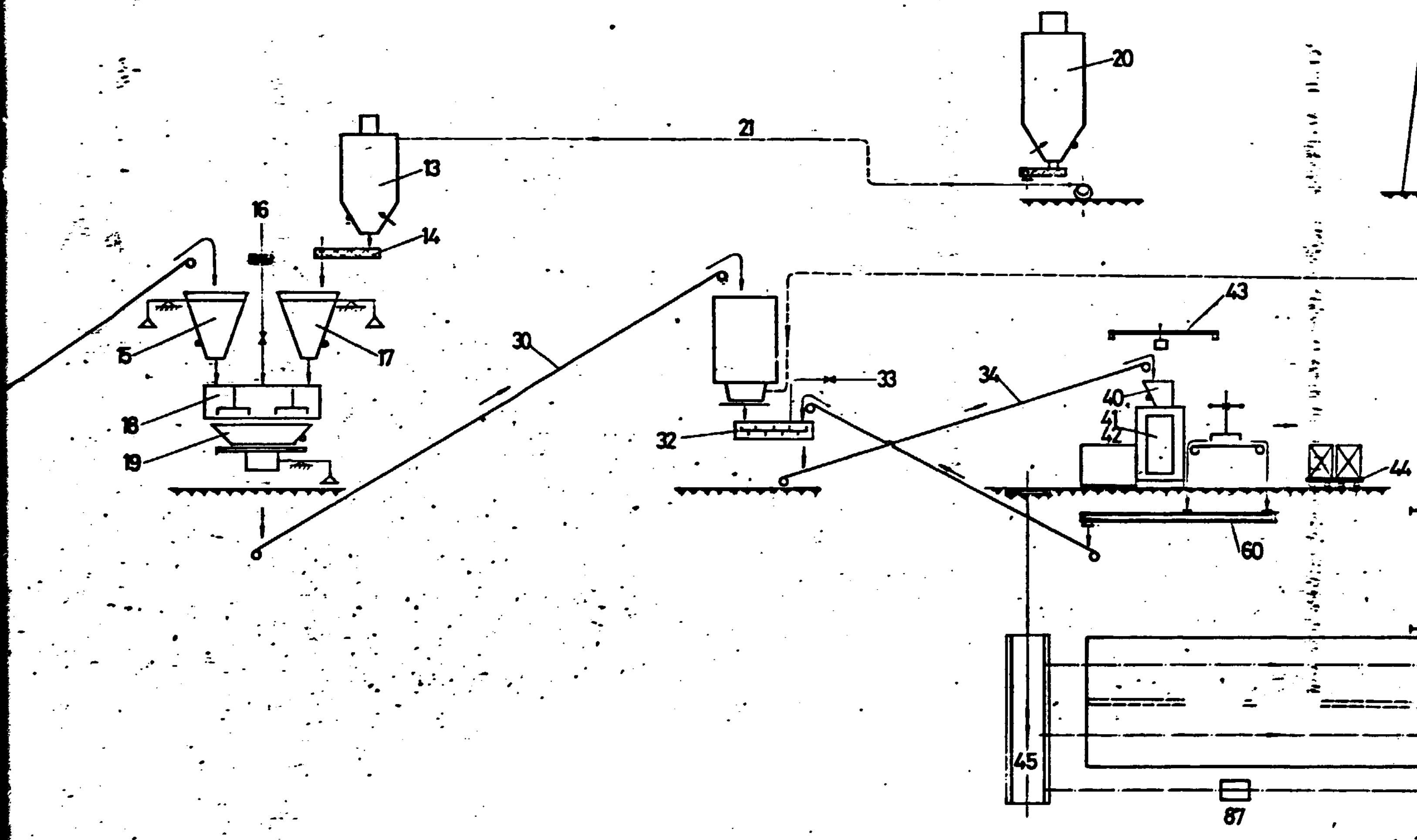

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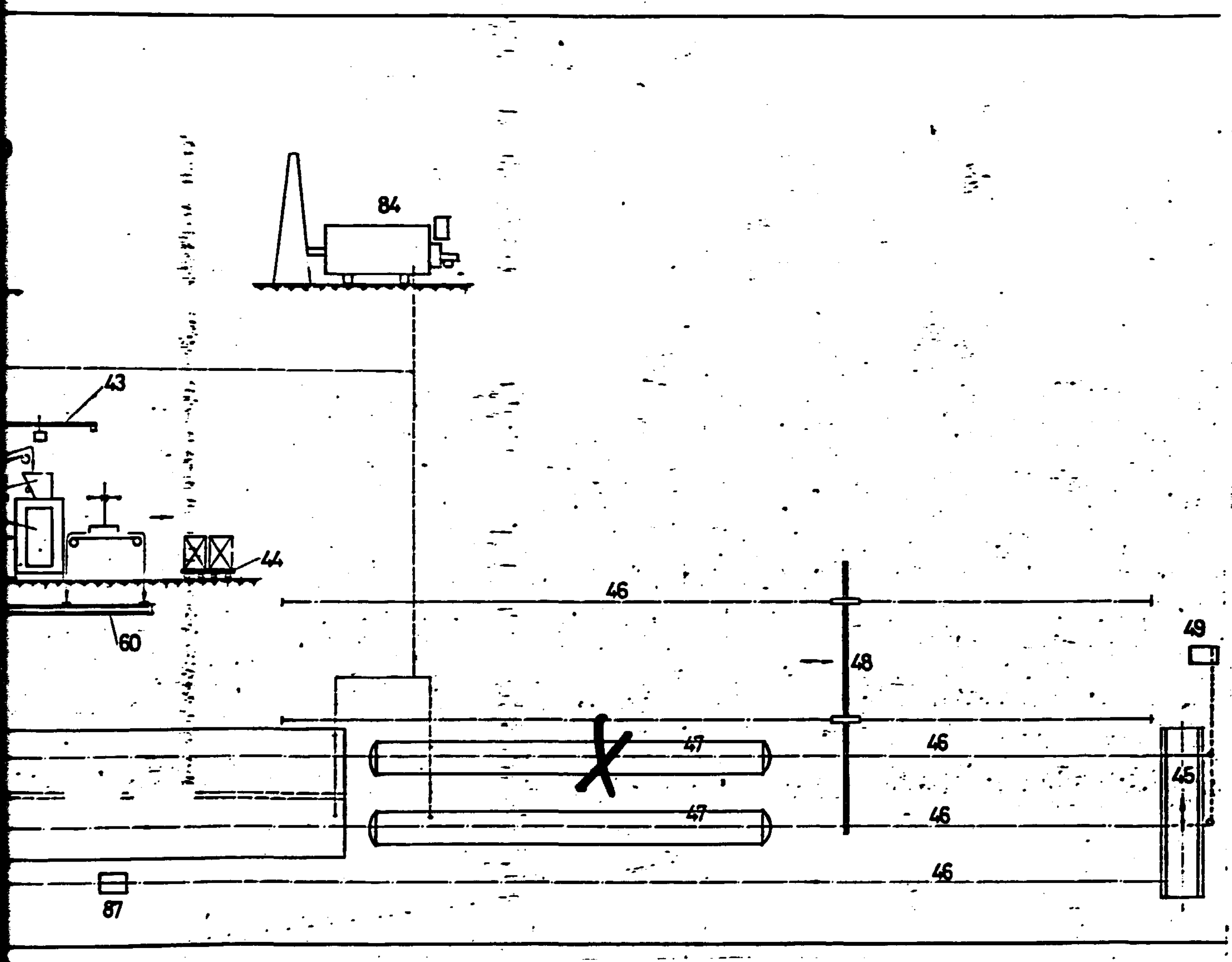

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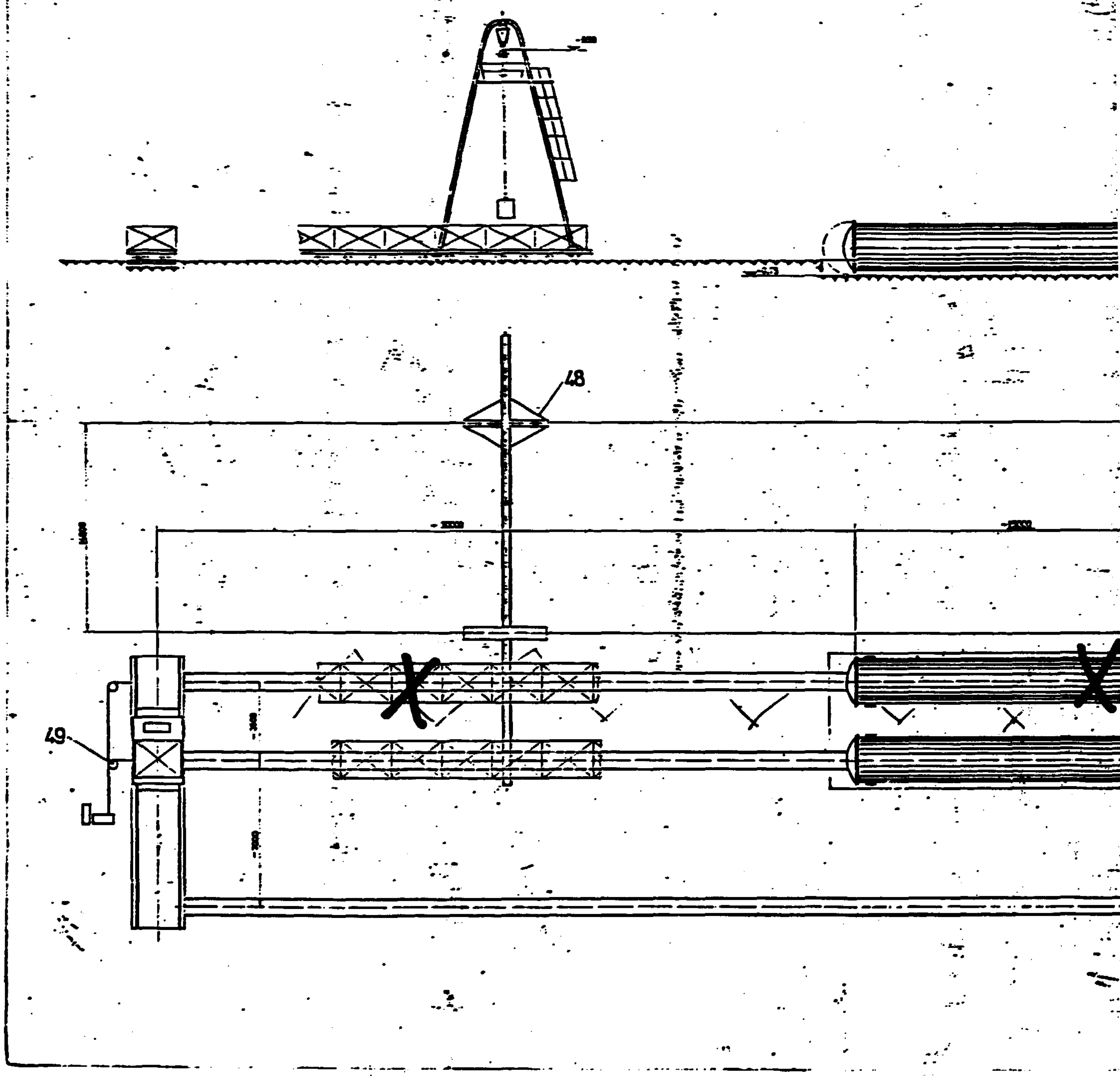

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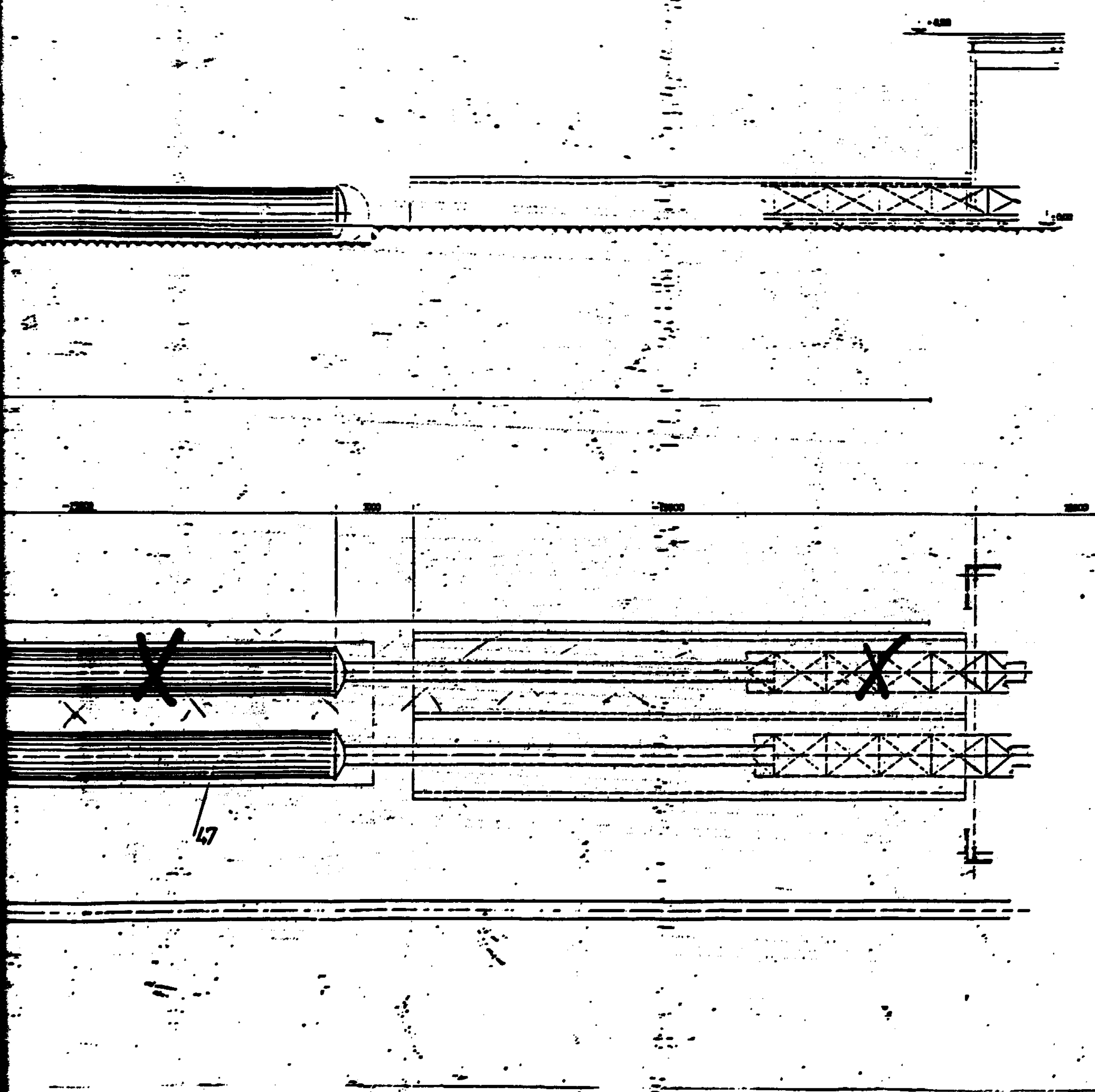

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