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Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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FINAL REPORT

Project Number DP/IND/81/015

Project (R)Techno-Economic Study and Pilot-Scale Testing on Garnet Concentrates for the Production of Building Materials in India

UNIDO Contract No. 84/122

Prepared by Mr. Ferenc PUSKÁS, ceramic expert

September, 1986.

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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 garnet sand waste utilization for the production of building materials, elaborated by Mr. Ferenc Puskás.

Based on a field trip, laboratory tests of garnet sand and various mineral additives, all of Indian origin IRE-OSCOM, the following findings have been made and are reported in greater detail in this Report.

1/ Garnet sand from the pilot plant production of IRE OSCOM in Chatrapur is the waste of the production, can be combined in formulas with additives to yield products of excellent quality parameters. Possible products include glazed floor- and wall tiles by single firing technique, architectural glass and walling bricks, by cold technology. The garnet sand content of such products range up to 5o-6o p.c.

2) Considering the size of the Indian building materials market the amount of garnet sand 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 to the energy requirement of the traditional technique. The suggested method of single-firing has been a result of great importance all over the world.

5) On the basis of laboratory tests it is proposed thata plant be built to produce 2.ooo.ooo sq.m. floor and wall tiles per year. Capacity can be increased according to the requirements. One part of the equipment of the plant is of local manufacture. The value of the import equipment does not surpass 4,5 million US dollars. The economic calculation in this reapect can be found in the further part of this Report detailed

The settlement of the plant enables the furtner development of the industry and the use of the products for the local communal buildings. In addition a lot of cities are within some hundreds of km radius (Bhubaneswar, Calcutta) thus the transport problems can be reduced to a minimum. The garnet sand based product produced in Chatrapur permits a flexible market strategy because the raw materials is available practically free.

According to the economic calculations for the erection of this plant the investment costs has been 191 mill.Rps for building 15 mill Rps included. Total capital requirement has been 2oo mill Rps. Payback period: 2 years, net cash flow 43 mill Rps/year.
It is recommended that the Governemnt of India encourage a garnet sand 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.

6/ On the basis of the results of laboratory test and pilot scale demonstration the erection of a plant producing calcium bond walling bricks with a dimension of 22ox11ox55 mm by cold technology with an annual capacity of 1o mill pcs can be suggested. Investment cost of such a plant has been 1o mill Rps. The energy saving of this plant in comparison to the traditional brick production has been 3o p.c. Payback period of the factory has been 3,97 years. Net cash flow: 1 mill Rps/y. The technology utilizes 11.ooo t garnet sand and 8.8oo t quartz sand.

7/ On the basis of the laboratory testing garnet in a purity of 97 p.c. can be used for glass production as well. Investment cost of such a production can be reduced to a minimum because existing glass factories can be used with a minimum reconstruction in the mashine line.

CHAPTER TWO

Project Background and Project History

Project Background and History

2.1. Project Background

On the basis of his previous experiences in ceramics technology, the author, Mr. Ferenc Puskas, 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 itmes such as glazed tiles and frost-proof porous products.
- More red mud (over 5o p.c.) 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 materials 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 number of other countires. It was also treated in outline in a Hungarian document complied for the UNEP conference on environmental protection for the alumina indusgtry 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 in the list of recommendations adopted by the conference. Several delegations were interested in studies geared to the countires' respective conditions.

On the basis of the recommendation of the conferenc 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 wich 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 materials purposes. The commission was given and the feasibility study and economic par was successfully elaborated and completed by Mr. Puskás.

In September 1984 UNIDO invited firms to give offer for the preparation of a Study aiming the utilization of red mud waste of the production of BALCO alumina factory. The draft final report in this thema was prepared in April 1986.

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

On the basis of the preliminary document UNIDO approved the plan of work and the calculation of the 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 garnet sand of IRE-OSCOM plant and other local low value materials, and conducting pilot scale testing for processability to building-construction materials for demonstration scale production of bricks, blocks, tiles, architectural glass etc.

Following the de-briefing of the team on 8 Feb. 1985 at UNIDO, an Amendment No. 1 was accepted to the contract between UNIDO and Licencia in this project. Therefore both 80 % and 97 % garnet were tested as described in the further parts of this study in comparison to the original scope of work in the Contract.

In conformity with the above this study deals with the quality of the producable goods, the optimation of the manufacturing technologies in respect to the precessing possibilities of garnet sand of IRE-OSCOM plant, elaborated by Mr. Puskas.

Thus the present Study is concerned with the use of garnet sand in a purity of 97 p.c. and 8o p.c. for purposes of the building material industry specifically in India-Orissa. The garnet sand in a purity of 97 p.c. was investigated for the purpose of architectural glass production, while the garnet sand of 8o p.c. purity was tested for the purpose of cold-bond walling bricks, glazed floor and wall tiles, and architectural glass.

Therefore, the results, conclusions and facts established in this Paper should not be understood to refer to the garnet of any other country only to Messrs. IRE-OSCOM, Orissa, India.

2.2. Project History

After the respective subcontract entered into force, the Hungarian expert team headed by Mr.Puskás team leader, Miss V. Papp project coordinator, Mrs. Batri consultant received their briefing on the project from Mr. Surgucov, UNIDO, Vienna.

A field trip aimed at the familiarization with the local conditions and selection of the potential additives took place in January 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 Orissa 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 the garnet sand of IRE-OSCOM and additives yield mixtures which are suitable for the production of architectural glass in a purity of 97 p.c., and for the production of cold-bond and fired brick, walling block and glazed floor- and wall tile by using garnet sand of 8o p.c. purity, of the required quality fired out in electric kiln.

Following the evaluation of the laboratory tests the author requested Messrs. IRE'OSCOM to send the following materials to Hungary.

garnet sand in a purity of 97 p.c.	1 ton
garnet sand in a purity of 8o p.c.	1 ton
Orissa sand	1 ton
(Rushikulya river)clay	o,5 ton
kaoline	o,5 ton

Pilot testing and demonstration was performed in the second half of June 1986, after the review meeting in India, in conformity with the agrreement with UNIDO of 9th April 1986, at the Kochel am See facility of Messrs. DORST Maschinen und Anlagenbau, something that is 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 materials. 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 garnet sand project is the first complete job that need all their equipment to perform.

CHAPTER THREE

Technical Report

5.1. Geological survey and investigation

3.1.1

Geological summary on the basis of the information of the Directorate of Mining & Geology, Govt. of Orissa

A profile of mineral Development in Orissa

Setting

Orissa State, on the eastern sea board of India, is known for its rich, varied and abundant mineral resources. All the rock formations in the geological time scale, comprising the oldest "Archaean", younger coal bearing Gondwanas and the recent laterite, soil and alluvium make up the landmass of the State. The Archaeans, by far, are the most dominant, occupying about three-fourth of Orissa's landmass. These formations host the minerals and ores that are needed for sustenance and economic development.

Exploration

Since the dawn of civilisation, search for minerals has remained the most exciting and rewarding venture of mankind. Mineral resources are finite. With depletion of mineral resources at a much faster rate in recent years, greater efforts to locate additional resources worldwide, have become expedient.

In Orissa, exploration and assessment of mineral resources are carried out by the State Directorate of Mining and Geology and Geological Survey of India. Organisations which have supplemented the efforts of the DMG and GSI in undertaking a comprehensive assessment of the mineral potential of the State include the Orissa Mining Corporation, Atomic Minerals Division, Indian Bureau of Mines, Oil India Ltd., Mineral Exploration Corporation, Steel Authority of India Ltd., Coal India Limited, TISCO. Ltd. among others.

The combined efforts of all these organisations have enabled the State to occupy a pre-eminent position in the mineral map of India in spite of the fact that geologically favourable areas are yet to be fully covered by air borne survey and large parts of potential mineral bearing area, both onshore and offshore, remain to be investigated in detail.

Discovery of over a billion tonnes of metallurgical grade bauxite in the high plateau of Koraput and Kalahandi, proving of 13o million tonnes of chromite in Sukinda valley; discovery of thick coal seams in both Talcher and Ib Valley coalfields, copper ore in Sambalpur, tin ore in Malkangiri sub-division of Koraput district and limestone in the districts of Balangir and Kalahandi during the last decade are significant landmarks in the history of exploration in Orissa State.

Resources

Orissa is generously endowed with mineral resources. The State possesses about one-third of the total resources of Iron ore and Manganese ore, 95 per cent of the resources of Chromite and 60 per cent of the resources of Bauxite of the country.

The country's only known commercially workable deposits of Nickel ore occur in Sukinda valley of Cuttack district.

The resources of Limestone, Dolomite, Graphite, Fireclay, China Clay, Quartzite, Mineral Bearing Sands are vast and extensive.

The other important possessions include ores of vanadium, copper, lead and tin; precious and semi-precious stones, Kyanite, Soapstone, Felspar, Mica, Asbestos, Pyrophyllite among others.

A variety of rocks suitable for building, construction and decorative purposes occur in different parts of the State.

The present status of resources of different minerals and ores is as follows:

	/million tonnes/
Bauxite	1,525
China Clay	35
Chromite	130
Coal	6,300
Copper ore	3
Dolomite	475
Fireclay	59
Iron ore	3,120
Lead ore	26
Limestone	850
Manganese ore	31
Mineral sands	46
Nickel ore	155
Quartz and Quartzite	15
Vanadium ore	2

While the reserves of the above minerals and ores are being continuously updated, resources of others are being assessed.

Development

The State is the leading producer of Chromite, Dolomite, Manganese ore and Graphite in the country.

Orissa is one of the major producers of Iron ore, Fireclay, Limestone, Quartz and Quartzite.

As many as 61o mining leases have been granted for different ores and minerals in the State. The total area covered by mining leases is 1,311 sq. Kms. constituting about 0.8 per cent of the area of the State.

The total production of ores and minerals in the State was 14 million tonnes, valued at Rs. 135 crores /1983/.

Production of different ores and minerals in 1983 was of the following order:

	/thousand tonnes/
Iron ore	5,667
Manganese ore	459
Chromite	285
Lead ore	43
Limestone	2,854
Dolomite	786
Coal	3,769
China clay	27
Fireclay	110
Graphite	28
Quartz & Quartzite	64

Export was confined to Iron ore and Chromite, the respective figures for 1983-84 were 9.29 lakhs tonnes and 0.82 lakh tonnes.

The Mining industry provides direct employment to about 50,000 persons.

Mineral revenue is now of the order of Rs. 13.39 crores /1983-84/.

Organisation

Systematic exploration, assessment and exploitation of the mineral resources of the State; administration of mines and mineral concessions in accordance with the provisions of the Mines and Minerals /Regulation and Development/ Act, 1957 and co-ordination of activities, relating to mineral development are the objectives and activities of the Mining and Geology Department. These are discharged through the Directorate of Mining & Geology and its field establishments.

The Orissa Mining Corporation Ltd., established in the year 1956, has the distinction of being the pioneer undertaking in the public sector in the country for development of mineral resources. O.M.C. is the largest producer and exporter of chrome ore and a leading producer of Iron ore and Manganese ore in the country. The Corporation's other current mining activities include extraction of tin ore, fireclay, limestone, china clay and precious stones.

It has plans to develop mines for production of Graphite and facilities for processing of dimension stones. O.M.C. has taken steps to set up plants for benefication of low and off grade chrome ore and clay. The Corporation is now operating 22 mines. Its sales turnover was Rs. 15 crores during 1983-84.

A subsidiary of O.M.C. named "OMC ALLOYS Ltd." was formed in the year 1982 mainly for the purpose of commissioning and operating the 50,000 tonne/year capacity Charge Chrome Plant, under erection near Bemnipal in the district of Keonjhar. Estimated to cost Rs. 48.55 crores' the loo per cent export oriented project is expected to go into commercial production by the middle of 1986.

Mineral-based Industries

The industrial scene in Orissa is dominated by the integrated Iron and Steel Plant of SAIL at Rourkela. The massive Bauxite-Alumina-Aluminium complex of NALCO earmarked for commissioning around 1986-87 will be perhaps the largest mineral based industry in the country. The other industries worthy of mention, include:

Ferro Manganese plants at Rayagada and Joda

Pig iron plant near Barbil

Ferro-Silicon and Silicon metal at Theruvalli

Refractory plants at Belpahar, Rajgangpur, Latikata, Dhenkanal and Barang

Glass and Ceramics at Barang

Cement plants at Bargarh and Rajgangpur

Fertilizer plants at Rourkela and Talcher

Thermal Power Plant at Talcher

Ferro-chrome Plant at Jajpur Road

Charge Chrome Plant near Bhadrak

Sponge Iron Plant near Palasponga

Graphite benefication plants at Sargipali, Tumudibandh, Balangir, Titilagarh, Belpara, Mahanilo

Ceramics and Insulators at Kuldiha and Jharsuguda

Lead concentration plant at Sargipali

Chrome ore benefication at Boula

Chrome Chemicals.

The plants which are under erection include:

Sponge iron plant near Bilaipada

Charge Chrome plant near Bemnipal

Fertilizer plant at Paradip

Heavy minerals separation plant near Chatrapur

Mini cement plant in Sundargarh district.

The mineral-based industries planned to be set up include:

Nickel/Ferro-nickel

Ferro-Vanadium

Electrolytic Manganese Dioxide

Manganese metal

Chrome metal

Charge Chrome at Choudwar

Iron and Steel near Daitari

Cement plants in Koraput and Sundargarh districts

Super Thermal power Station at Talcher

Thermal Power plant near Belpahar

Captive Thermal Power Plant at Choudwar

China clay washery in Mayurbhanj district

Chrome ore benefication in Sukinda valley

Graphite benefication near Muniguda.

Prospects

For a State endowed with such a wide variety ores and minerals, systematic and expeditious development and utilization of mineral resources are essential for steady and sustained economic growth.

The development programme has to take into cognizance the need for intensive and accelerated exploration activities including airborne survey and remote sensing. There are indications about economic concentrations of gold, tungsten, lithium, platinum, apatite, asbestos /chrysotile/ in some parts of the State. All these merit detailed investigation.

The prospect of locating oil in the offshore and onshore areas of the State, where geological conditions are favourable, should be fully assessed and re-investigated wherever necessary.

With the stepping up of exploration activities, facilities for instrumental analysis and application of modern techniques in exploration will have to be introduced.

Development of mineral resources depends to a large extent on availability of essential infrastructure facilities such as rail and road communication, power, water and port. The railway projects connecting Banspani with Daitari and Koraput with Rayagada have been sanctioned by Government of India. Recently construction of the railway line connecting Talcher with Sambalpur has been sanctioned. Construction of these railway projects is expected to be completed by the end of the 7th plan period. These will help in accelerating mineral development in the State.

The port at Paradip has been handling iron ore, chrome ore, coal and mineral products besides a wide variety of general cargoes. The wagon tippling system has already been commissioned. The port has to be developed including deepening of the harbour to accommodate bulk carriers for iron ore export.

The state is endowed with very large reserves of power grade coal. The reserves proved so far, which are amenable to quarrying, can sustain generation of 10,000 MW of power for a period of 100 years. It is in this field that there is unlimited scope for development of coal resources and installation of additional capacities for generation of power. This is necessary as development of mineral industries and particularly production of ferro-alloys reqire large chunk of power.

The State possesses large surplus reserves of bauxite. There is good scope for export of bauxite both in crude and calcined form.

The vast and varied minor mineral resources have remained practically untapped. These can be developed for export and also for meeting the requirements of the domestic building and construction industries. There is also scope for export of washed china clay and beneficiated graphite.

Technology is established for production of iron by the sponge iron route utilizing non-coking coal. Processes have been developed in Sweden and West Germany for production of iron utilizing non-coking coal. The future production of iron and steel in the State, of which there is immense scope, would take into account all such processes.

Production of charge chrome from off-grade chrome bearing material and low to medium grade chrome ore fines involving adoption of the latest technology, marks an important step in mineral development in the country. The State is poised for production of 150,000 tonnes of charge chrome annually, all earmarked for export. Besides introducing new technologies, the ventures will earn foreign exchange equivalent of Rs. 75 crores annually.

Government of India are examining various proposals to select a viable process for extraction of nickel from the ores of Sukinda valley. The State possesses adequate reserves of minerals and ores for production of various types of ferro-alloys. Establishment of a modern stainless steel manufacturing unit, with charge chrome and nickel as the basic input, is a distinct possibility.

The Orissa Mining Corporation Ltd. has stepped up its activities in the chromite mining field, to cater to the increasing demands of export and requirements of indigenous metallurgical, chemical and refractory industries. Its annual sales turnover is likely to touch Rs. 25 crores during 1984-85.

Concurrently with the development of mineral resources, measures have to be considered and implemented to minimize degradation of the environment. This important aspect is now being locked after by the State Prevention & Control of Pollution Board; Department of Science, Technology and Environment and the Directorate of Mining & Geology.

The contribution of the mineral sector to the economic development of the State has been particularly noteworthy during the 6th Plan Period. Its contribution to the State exchequer is expected to be of the order of Rs. 59 crores during the 6th Plan. The scope for mineral development and development of coal resources in particular are indeed enormous. Given the required input for development of essential infrastructure facilities, installation of additional capacity for generation of thermal power based on the coal rescurces, it would be reasonable to expect the mineral sector to contribute substantially to the economic growth of the State during the 7th Plan Period.

3.1.2. Geological Investigation of Samples

Samples were taken from the valley of Rushikulya river (Orissa state). Ssurface is being cultivated by local farmers.

Clay deposit is situated below the surface from o,5-lo to 5.o-6.o m and is exposed in wells clay deposit covers about an area of 25 m2.

Clay is yellow and grayish or greenish yellow in colour, it has an uneven earthy-like fracture. By megascopically fine grained non-altered rock fragments can be distinguished.

Clay is very fine grained no more than fifteen p.c. is in the silty fraction only.

As far as mineralogy is concerned the clay can be characterized by some montmorillonite content, kaolinite is the dominant clay mineral.

Chemical composition

Chemical composition of the tested sample is as follows;

Loss on ignition	10.26 %
SiO_2	58,36
Al_2O_3	18,60
Fe_2O_3	6,16
TiO_2	0,86
CaO	2,15
Na_2O	1.86
K_2O	1,08

Grain size distribution of garnet

grain size in µm	purity 97 %	purity 80 %
above 800	-	-
630 - 800	0,91	0,85
500 - 800	8,98	7,48
400 - 500	13,13	14,95
315 - 400	22,22	20,94
200 - 315	48,42	49,66
160 - 200	3,96	4,83
125 - 160	2,15	0,86
100 - 125	0,36	-
- 100	-	-
Loss	0,17	0,43

Chemical composition of garnet

	97 %	8o %
SiO_2	38,2	37,2
Al_2O_3	2o,6	2o,2
Fe_2O_3	2,4	-
TiO_2	o,3	3,1
CaO	2,6	2,3
MgO	6,7	6,2
K_2O	o,o1	-
Na_2O	o,o3	-
SO_3	o,1	-
FeO	27,1	3o,o
MnO	1,1	1,1
P_2O_5	o,1	-

3.2.

Strength testing of walling elements made of garnet sand, quarz sand and lime both of Indian origin

Aim of the testing

was to investigate the feasibility of the manufacturing of walling elements meeting the strength requirements made of the mixture of garnet sand and quarz sand by calcium-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 sand is under 1 mm.
- 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 garnet sand 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 tendendy
- The volume density of the probe bodies irrespectively of their composition has been 1400 kg/m^3 which means in comparison to the volume density of a normal clay brick /1700 kg/m^3/ a lower value.

Table No 1.

Mechanical Characteristics of probe bodies made of garnet sand, quarz sand and lime, all of Indian Origin

No	Composition	Characteristics	1.	2.	3.	Average
I.	garnet sand 60 % quarz sand 30 % calcium hydrate 10 %	volume density /kg/m3/	1281,3	1340,0	1297,0	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.	garnet sand 50 % quarz sand 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	14,40--14,00	14,13
III.	garnet sand 40 % quarz sand 30 % calcium hydrate 30 %	volume density /kg/m3/	1400,8	1308,6	1308,6	1306
		bending strength /MPa/	2,49	2,55	2,66	2,57
		compression strength /MPa/	16,4--16,00	15,6--15,20	13,60--13,20	15,00

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

On the occassion of the visit of IRE-OSCOM representatives dated 23 June- 9.July 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 kg garnet
400 kg quartz sand
100 kg lime hidrate calculated on CaO basis

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 lime is sladed in the reactor.

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

3.4 Laboratory investigation of 8o p.c. purity garnet sand, by-product of IRE-OSCOM and of other waste deposits and mineral resources of Orissa area from the point of view of utilization of garnet sand as the raw material of different construction matters

Using the garnet sand waste for the purpose of producing various covering tiles the garnet samples of different purity (8o p.c. and 97 p.c.) and Rushikulya river clay ingathered directly for this purpose on the spot personally were taken into consideration.

In accordance with the preliminary research plans the garnet sand in different purity and pertencage was used in elaborating the final composition.

At determining this final composition the following aims were respected;
to reach the possible highest ratio of garnet sand at the same time of achieving the optimal quality level of the targeted product, condiderating the local circumstances in the point of view of the manufacturing security. By the selection of other additives the long-term availability of theirs was also regarded.

Optimation of technology

In the first approach 6o p.c. garnet sand and 4o p.c. Rushikulya river clay 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. Its optimal moisture content is around ten percent.
If the powder is not dry enough 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.
The pressed and dried pieces were burnt at a temperature of 1o5o °C. The shrinkage during burning was sufficient and water absorbability was 11 p.c.
This kind of clay shows advantageous features (i.e. plasticity, ability of turning into sludge more ieasily, diminishing the grinding period etc)

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.

During baking the pressed tiles in electrically heated laboratory kiln at a temperature of lo5o°C, 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.

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.

By firing on a temperature of lo5o°C and having 7o-75 p.c. garnet sand content in the mixture high strength products could be produced. This circumstance enable the economy and technical viability of fired brick production.

Chemical compotision of garnet sand (8o p.c. purity)

SiO_2	5o,4 p.c.
Al_2O_3	16,o
Fe_2O_3	-
TiO_2	2,5
CaO	1,8
MgO	5,o
K_2O	-
Na_2O	-
SO_3	-
FeO	24,o
MnO	o,75
P_2O_5	-

3.5.. Pilot Testing and Demonstration in West Germany with Messrs. DORST

TEST REPORT

on the production of ceramic wall tiles from a body with garnet components in single firing.

carried out for:

Licencia, Budapest

Hungary

licencia team included: Mr. F. Puskas ceramic expert team leader

Ms. V. Pap, project coordinator

Mrs. Batri, project consultant

Mr. K. N. PANIGRAHI, Deputy Manager IRE India

Mr. S. Suresh Kumar, Asst. Manager IRE India

by

DORST Maschinen und Anlagenbau

Mittenwalder str. 61.

POB 109 + 129

D-8113 Kochel am See

26. June, 1986.

DORST team included:

Mr. Roschlau, leader of lab.

Mr. Gräf, ceramic engineer

T E S T   R E P O R T

List of Contents

1. Scope of order

The aim of the visit of Licencia team, Budapest, was to investigate the possibility of production of tiles from a ceramic body with garnet components. Purity of garnet was 8o. p.c. A batch consisting of the 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
- firing of the glazed tiles.

The t sts have been carried out in the Test and Research Centre in Kochal am See from 23rd to 27th June, 1986 under the supervision of Licencia and with the participation of Indian delegates of IRE-OSCOM Chatrapur.

2. Performance and results

2.1. Boddy preparation

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

3oo kg garnet of 8o p.c. purity

2oo kg clay

332 l water

The raw materials had been weighed and ground in two batches of each 25o kg with 166 l of water in a wet grinding ball mill (Dorst NM 11o/9o).
Dorst Company placed at disposal the liquifying agent sodium-tripoli-phosphate. Thus, both batches were liquifying with o,251 p.c. of sodium-tripoli-phosphaete. The grinding time for each batch five hours. After this period of time the residue was smaller than 8 p.c. on a sieve with 63 úm 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) 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 3oo °C. The heating medium was liquid gas and the pre-heating of the air was done by 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 16o to 315 um. 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 /size 215 x 322 mm/ tiles with an edge of approx. 217 x 324 mm were produced. The specific pressing force was approx. 25o kg/cm2 at a tile thickness of 8,2 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 8o.p.c. purity garnet components has a good pressability and reacts relatively insensitive to change of pressing force.

2.4. Glazing

For the glazing of the tiles Company KERAprogress placed a liquified glaze at disposal wich based on a Zirconia 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 15oo g/l a very slow speed of the conveyor belt had to be chosed 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 scle 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.

The following temperature curves have been examined as to the four burner groups:

test No.	T1 in °C	T2	T3	T4	passage time in min.
1	95o	1o5o	115o	115o	93
2	95o	1o5o	11oo	11oo	93
3	85o	95o	1o5o	1o5o	1oo
4	85o	95o	1o5o	1o75	1oo
5	75o	9oo	98o	98o	6o

Without glaze the optimum temperature for the firing of unglazed tiles without any torsion:

78o	96o	1o9o	1o8o	8o

Test No.1.

In this adjustment a deformation of the tiles resulted with the corners bulging.

Test No.2.

With this considerably higher temperature the bulging corners flattened again. When the sintering process set in heavily at 115o °C the tiles were even more deformed.

Test No.3.

The bulging of the corners was reduced by decreasing the maximum temperature to 1.o5o as opposed to 115o °C in the first test, however, the glaze revealed heavy blistering.

Test No.4.

By increasing the temperature in the last phase of the firing process T4 a better disbtribution of the glaze was achieved, however, still the formation of blisters was noticed.

Test No.5.

Aster reducing the temperature in the heating up phase (T1 and T2) and after reducing the passage time a distinct decrease in blister formation was noticed.

The tiles fired in test 5 revealed in isotropic firing shrinkage of o,oo p.c.

2.6. Laboratory tests

By means of a three point device the modulus of rapture of the tiles were tested before and after drying. The results have been listed in annex 3.

As to the modulus of rupture in undried green tiles it has been 11,5 kg/cm², while after drying it has been 11,76 kg/cm².

Semi industrial Trial

Spray drying

Annex.1.

Garnet test

PROJECT / CUSTOMER : Licencia, Budapest
ORDER NO. :
BODY : tile
DATE : 23.6.86.

Solids	500	kg		60	%
Water	330	kg		40	%
Deflocculant		kg	Sodium-tripoli-phosphate	0,251	%
Liter weight	1715	g/l			
Viscosity	600	cP			
Residue on					%

Nozzle-upright :	1		Hot air	300	°C
Number Pcs. :	1		Waste air	85	°C
Nozzle Diameter :	1,9	mm	Tower	18	mm W.G.
Twisting worm :	6/4	mm	Main fan	180	mm W.G.
			Pump	20	kp/cm2

Residual moisture content :	5 %		Particle size distribution :		
Bulk density	1066	g/l	>500 micron	0,1	%
Granulated material		kg/h	500 - 400 micron	0,8	%
Water evaporation		kg/h	400 - 315 micron	4,8	%
Consumption of gas		m3/h	315 - 250 micron	19,5	%
Remarks			250 - 200 micron	31,1	%
			200 - 160 miron	17,7	%
			160 - 100 micron	17,3	%
			100 - 50 micron	6,7	%
			< 50 micron	1,2	%

Semi Industrial Trial on the Hydraulic Tile Press HPP 750

Annex.2. -1 -
Garnet test

PROJECT/CUSTOMER: Licencia, Budapest
Order no. :
Body : tile body
DATE : 25.6.1986.
Granulate moisture content: 5 p.c.
Quantity pressed : 500 kg
Press die : wall tiles
Size of press die: 215x322 mm
Size of ~~fillers~~ tile
Weight of tile: 1250 g

3x215x322=2077 cm2

Adjustment of machine: P_1=250 bar, P_2=120 bar

1st pre-pressing force: F_{V1} =60 t; F_{V1} spez. = N/mm²
2nd pre-pressing force: F_{V2} = - t; F_{V2} spez. = N/mm²
main pressing force : F_H = 660 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	40	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: wall tiles
Number of stripes: 7
Filling height: 18
Thickness of filler tiles mm
Green bending strength: 11,5 kg/cm2

Annex 3. Modulus of rupture after drying

---

pressing load	bar	25o
size in mm after drying		2oo,5 x 1oox3
modulus of rupture		
Pmax.	kg	7,55
Ls	cm	15,o
b	cm	2oo,5
a	cm	12,o
Rb	kp/cm²	11,76

P = fracture load

Ls = distance of edges

b = width of tile

a = thickness of tile

$$RB = \frac{3\ P_{max.}\ Ls}{2\ a^2 b}$$

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 garnet 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 us 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.

Laboratory investigation of high purity garnet (9o p.c.) sand for the purpose of glass production

Aim of the testing was to investigate the possibility of architectural glass production by using high purity (97 p.c.) garnet sand for the purpose of walling elements, architectural wall and floor coverings, solar collectors in black colour.

In order to reach above aim chemical and physical analysis of the waste materials have to be carried out. Two kinds of garnet sand were investigated. Number 1. is the garnet of 97 p.c. purity, number 2. is the garnet of 8o p.c. purity.

Physical characteristics of garnet sands

Table.I.

Grain size distribution (/um)	no.1.	no. 2.
above 8oo	-	-
63o - 8oo	o,91	o,85
5oo - 8oo	8,98	7,48
4oo - 5oo	13,13	14,95
315 - 4oo	22,22	2o,94
2oo - 315	48,42	49,66
16o - 2oo	3,96	4,83
125 - 16o	2,15	o,86
1oo - 125	o,o6	-
- 1oo	-	-
loss	o,17	o,43

The experiments were done on a GDR vibrating sieve. Time of vibration was lo minutes.

The data of Table I. show the indifference in grain size distribution of the two samples. 84-85 per cent of the grain ranges between 2oo-5oo μm which is considered very favourable. In case of glass melting materials of grain size above 6oo-8oo and under loo-6o μm are unfavourable. Big grains cannot insolve and therefore, remain unsolved and the small parts close air bubbles which weights the clearing.

Derivatographical experiment

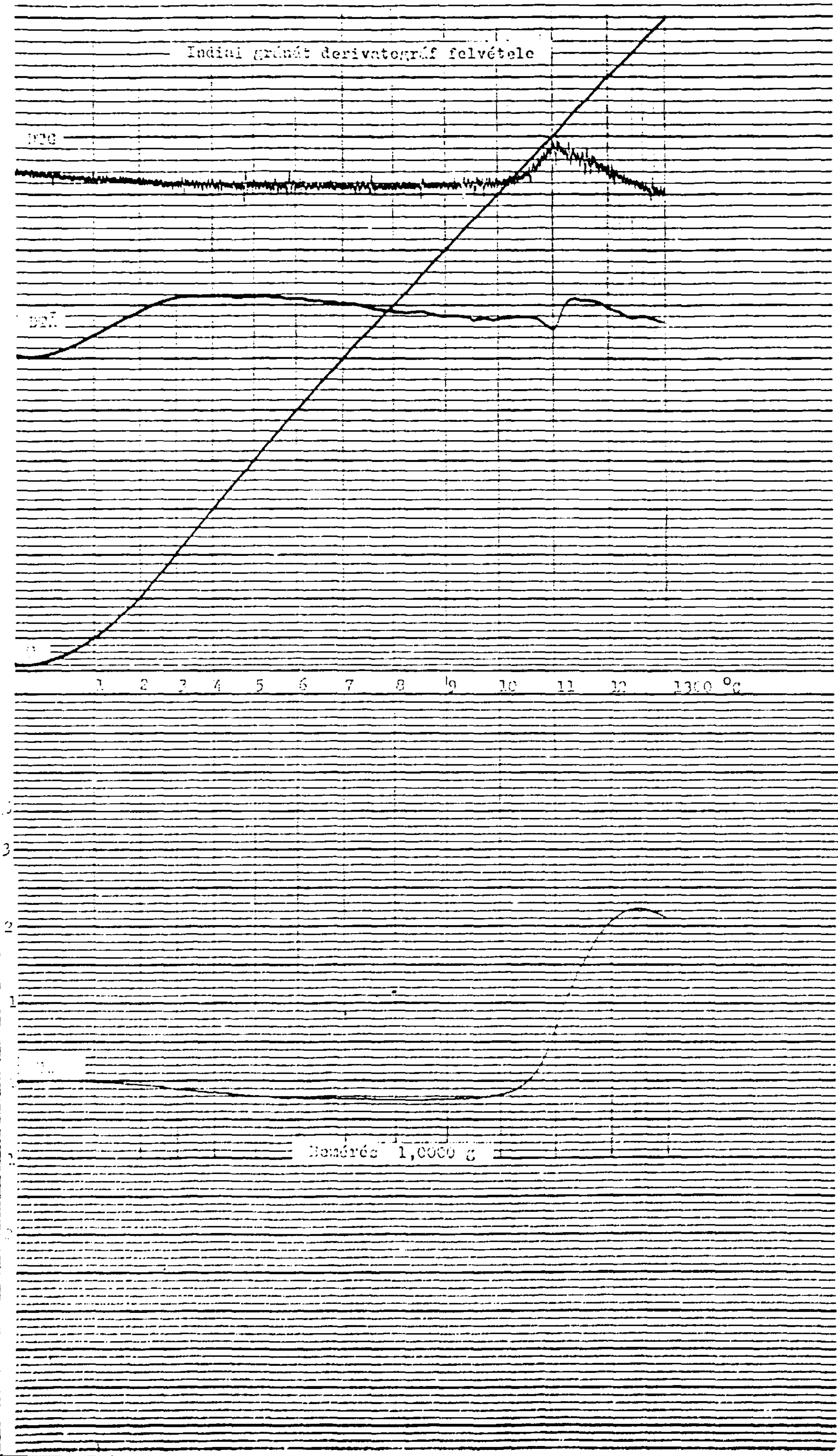
Measuring was carried out on a Hungarian devivatograph in a korund crucible on a temperature up till 13oo °C. According to the photo attached on a temperature of 1000 °C intensive volume increase begins, up till 124o °C. This can be caused by the FeO content of the garnet. Fe(II)O is inclined to convert into Fe(III)-oxyde on high temperature according to the formula given below;

$$4\ FeO + O_2 = 2Fe_2O_3$$

The change of volume is 2,95 p.c. which correspondes to 26,48 p.c. FeO content. The result of the two measurings can be considered paralel knowing their chemical composition.

The derivatogramm does not contain any effect regarding other reaction. The derivatographical photo of sample No.2. is not regarded because it does not differ from that of sample no.1.

Indiai gránát derivatográf felvétele



Testing of X-ray difraction

The mineralogical testing of garnet saples was prepared by the equipment of Regaku-Denki manufacture. The following page shows the mineralogical photo of the sample showing only almandin (or iron-garnet) between the peaks.

The ground line of the curve is high and refers to the Fe content.
The chemical formula of almandin is as follows;

$Fe_3Al_2(SiO_4)_3$ or

$Mg_3Fe_2(SiO_4)_3$ or

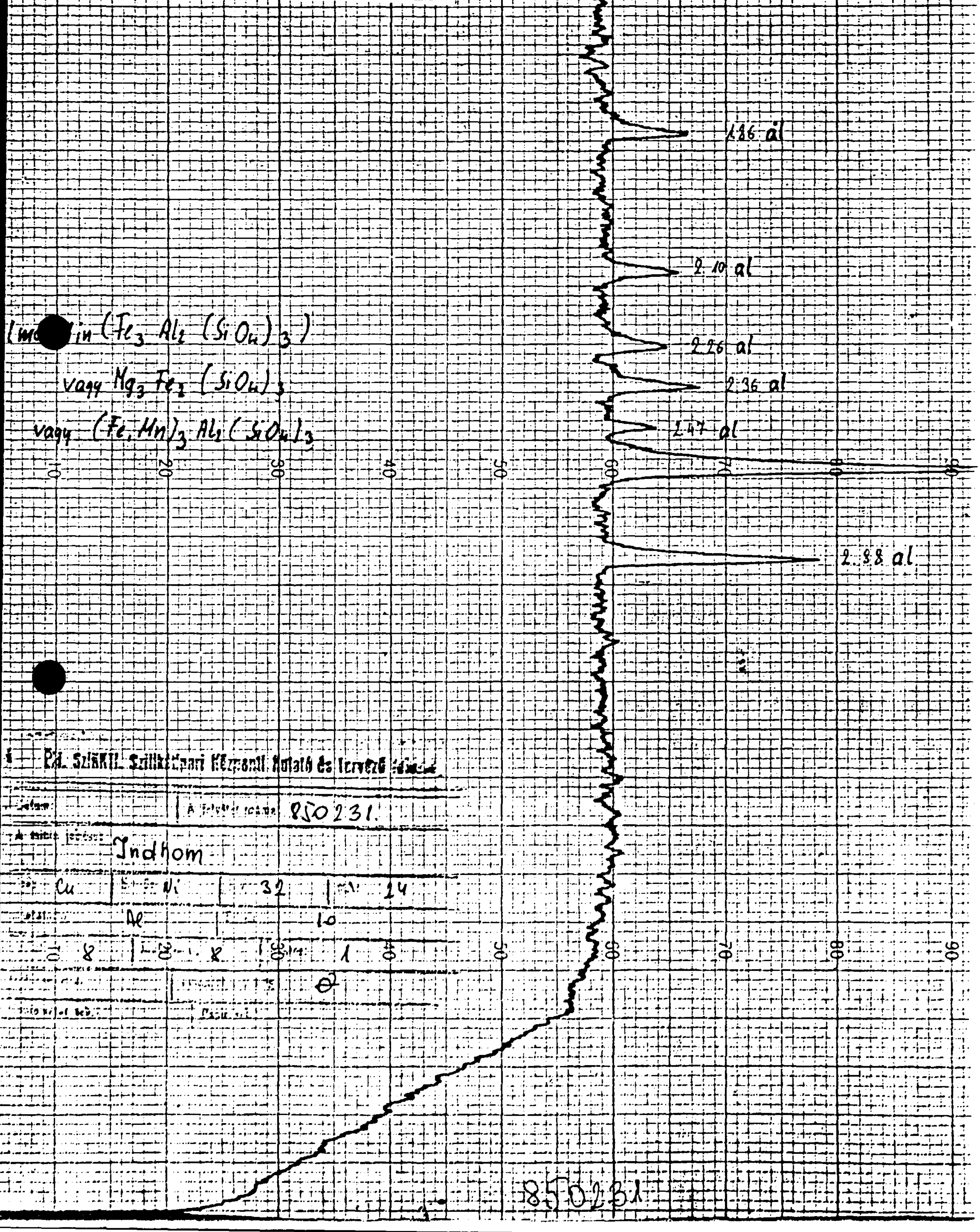
$(Fe,Mn)_3Al_2(SiO_4)_3$

The theoretical oxide composition of $Fe_3Al_2(SiO_4)_3$ is as follows;

FeO	43,2	p.c.
Al_2O_3	2o,5	p.c.
SiO_2	36,2	p.c.

On the X-ray diffraction photo other peak than almandin cannot be seen. The reasons of it; either it can be found in too fine distribution, or it is present in too low (insufficient) concentration.

A gránátok minaralógiai vizsgálatának felvétele



Heating microscopical testing

Testing was carried on a Leitz manufacture heating microscip, heating temperature up till 17oo°C. Pastilles were pressed of the testing materials which were placed on a korund plate. Photoes were made by constant speed, copies of which are attached. On the photoes it can be seen that no change it to be observed untill 11oo°C, its shape is unchanged in comparision to its state on a temperature of 2o °C. On 113o °C (photoes 41-42) little swelling can be seen which reaches up to 125o °C (photo 49-5o)

On the basis of these observations compared to the derivatogramm it can be stated that two measurings methods show identity to the behaviour of the material. On 13oo°C shrinkage is to be seen (photoes 51-52), On 133o°C the edges began to get round, (photoes 53-54). Melt-phase appears.
On 135o °C the edges dissolve (photoes 55-56), on a temperature of 136o°C its shape is almos hemisphere (photoes 57-58) and on a temperature of 14oo °C the garnet gets smooth on the plate, it moistens the surface (photoes 61-62), practically the whole quantity of the material is in melt-phase.

Chemical analysis of garnets

Chemical analysis of garnets is shown on the following table.

Table II.

	97 p.c. garnet	8o p.c. garnet
SiO_2	38,2	37,2
Al_2O_3	2o,6	2o,2
Fe_2O_3	2,4	-
TiO_2	o,3	3,1
CaO	2,6	2,3
MgO	6,7	6,2
K_2O	o,o2	-
Na_2O	o,o3	-
SO_3	o,1	-
FeO	27,1	3o,o
MnO	1,1	1,1
P_2O_5	o,1	-

On the basis of the analysis it can be stated that between the two garnets no difference can be seen, which could influence the characteristics of either sample. The Al_2O_3, Fe_2O_3, CaO, MgO and Mno content of garnets are identical, and their concentration on SiO_2, FeO and TiO_2 differ minimal from each other.

On the basis of SiO_2 and Al_2O_3 concentration a pure $Fe_3Al_2Si_3O_{12}$ would be supposed, however the FeO content is insufficient.
There are MgO and MnO in the composition which according to the above statements could be the components of garnet. TiO_2 and Fe_2O_3 content refers to the impurity of the material.

Melting experiments

On the basis of the tests and after the evaluation of the results specific glass compositions were searched which can be adjusted best to the composition of the garnet.

In the first approach glasses of high Al_2O_3 content and high Fe_2O_3 content could be donsidered where the presence of MnO is not disturbing.

The present available glass types are not suityble for this purpose. Glasses of high Al_2O_3 and Fe_2O_3 content are not suitable for mechanical processing.

13 different oxide compositions were taken where the quantity of the individual components has wide ranges. Concentration of the individual components ranges as follows;

SiO_2	41,5 - 67,o	p.c.
CaO	8,5 - 14,6	
MgO	o,6 - 7,7	
Na_2O	1,9 - 13,1	
Al_2O_3	5,9 - 13,5	
Fe_2O_3	1,3 - 19,5	
MnO	- 3,o	
BaO	- 1,3	
K_2O	- 3,8	

Oxide components of the individual glasses can be seen in Table no.III.

On the basis of this table and knowing the composition of the raw materials the necessary raw materials measuring was calculated, it is gathered in Table no.IV. The quantity of garnet in comparison to the whole raw material quantity is between 3,5 - 57,1 p.c.

The raw material mixture was melted after homogenization in a korund crucible, in laboratory circumstances on a temperature of 134o-14oo °C. The mixtures melted very quickly and became clear. In some cases corrision was to be observed the cause of which was the high Fe_2O_3 content.

From the melt sticks were streched in order to test the length of the stick. Stick marked by IG are short, the others are long glasses. This refers to the temperature invervallium where the glass is processable.

Oxide components of glasses (in p.c.) Table no.III.

Componenst of glass	IG-9	IG-8	IG-7	IG-6	IG-5	IG-4	KM3	KM2	8o)s	81)s	73)6	72)8	72)5
SiO_2	47,1	48,1	45,2	52,o	5o,1	46,5	61,5	41,5	56,6	64,7	67,o	61,o	61,6
CaO	12,4	11,6	8,5	9,o	11,o	14,6	9,9	16,1	14,4	1o,3	1o,5	1o,8	1o,6
MgO	5,8	5,9	4,8	6,3	6,8	7,7	6,1	2,6	1,2	o,6	o,6	3,4	2,9
Na_2O	2,3	2,3	1,9	2,1	2,8	3,8	2,8	3,7	9,o	12,6	13,1	11,2	9,5
Al_2O_3	12,9	13,1	1o,6	12,2	11,7	1o,9	13,3	5,9	12,4	7,5	6,4	1o,2	13,5
Fe_2O_3	18,8	19,2	15,4	17,8	17,1	15,9	2,4	1,4	2,5	1,4	1,3	3,4	1,8
MnO	o,7	o,7	o,6	o,7	o,6	o,6	3,o	2,1	o,1	o,5	o,1	-	-
BaO	-	-	-	-	-	-	o,3	1,3	-	-	-	-	-
K_2O	-	-	-	-	-	-	-	o,5	3,8	2,4	1,1	-	-

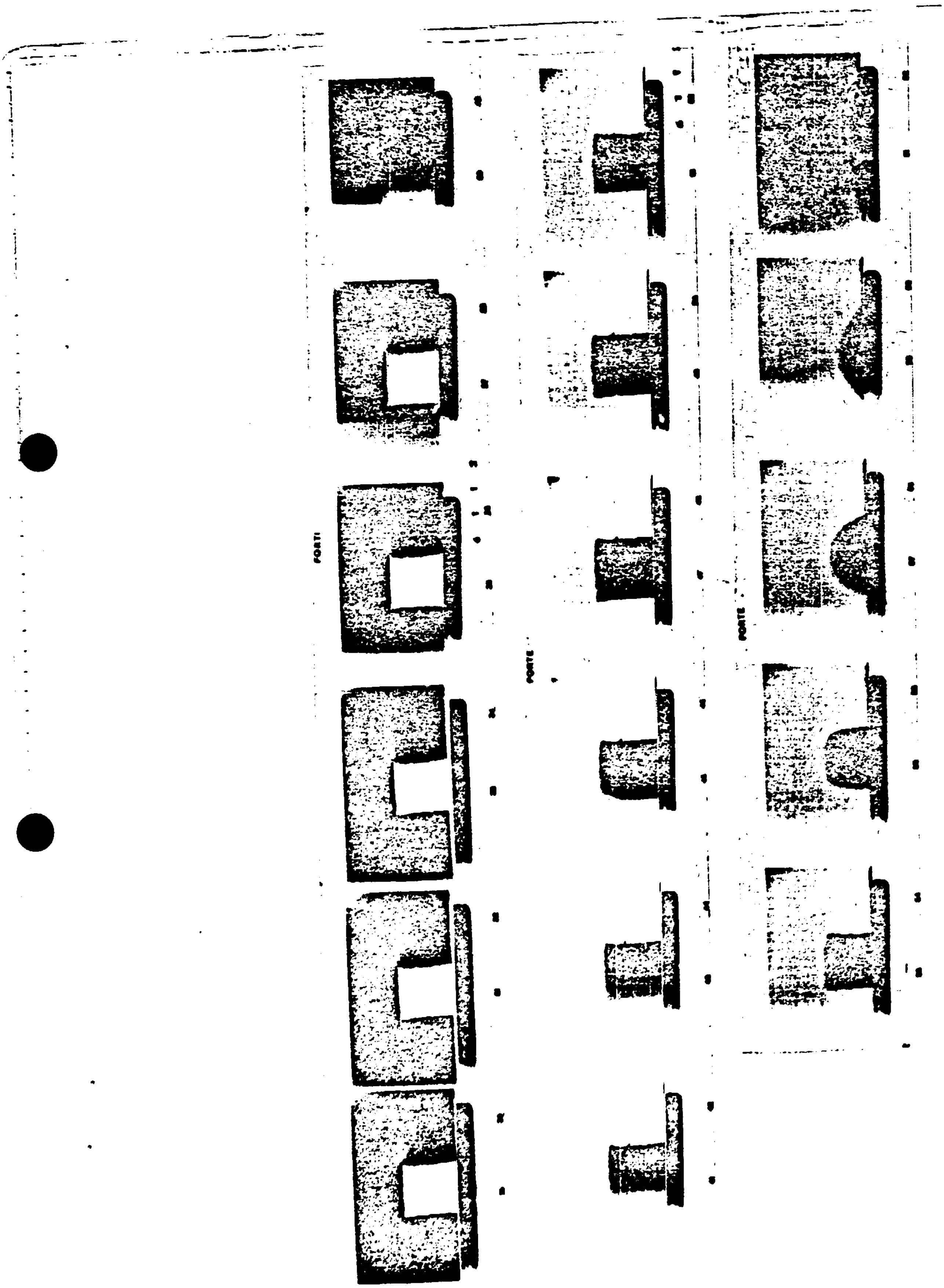
Measuring of raw materials mixtures (in g) Table. no.IV.

raw materials	IG-9	IG-8	IG-7	IG-6	IG-5	IG-4	KM3	KM2	8o)s	8o)s	73)6	72)8	72)5
sand	6o	6o	8o	8o	6o	4o	348	324	266	318	33o	283	3o1
lime stone	4o	3o	3o	2o	2o	2o	-	2o2	12o	92	93	62	64
dolomit	2o	2o	2o	3o	3o	3o	156	88	15	6	7	61	59
soda	1o	1o	1o	1o	1o	1o	29	51	72	1o4	1o8	93	78
garnet	16o	16o	16o	16o	12o	8o	48	37	42	24	21	56	31
alumina	-	-	-	-	-	-	69	4o	53	33	28	39	62
potash (black ash)	-	-	-	-	-	-	16	6	28	18	8	-	-
fluorspar	-	-	-	-	-	-	11	1	-	-	-	-	-
$BaCO_3$	-	-	-	-	-	-	2	13	-	-	-	-	-
MnO	-	-	-	-	-	-	17	17	-	2	-	-	-
bone powder	-	-	-	-	-	-	7	9	-	-	-	-	-

Summary

Garnet was tested from the point of view of utilization of glass industry. The following statements can be taken.

- Due to its high FeO and Fe_2O_3 contnet it is suitable to produce glack glass. Its Mno concentration strengthens the above characteristics.
- On the basis of the Al_2O_3 quantity glasses of high aluminiumoxide content can be produced.
- Garnet cannot considered to be a traditional raw material, inspite this fact it can be excellently used for the tested purpose.
- Ratio of raw material in the compositions ranges between 44 - 57,1 per cent.



3.7.

Technological description and specification of a brick factory for the production of universal walling blocks of OSCOM garnet sand based cold technology with an annual capacity of 10,000,000 pcs with a dimension of 220x110x55 mm, to the feasibility study

Content

3. Technical dta

3.1 Production data

3.2 Material demands /garnet sand, quartz sand, lime and 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 garnet sand from the sand reservoir near to the OSCOM plant, it goes to the drying area by conveyor. Finally it is sieved and conveyes to the brick production. The lime is 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 basis 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 grey solid brick in one size, 22o x 11o x 55 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 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 '/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 garnet sand, quartz sand, lime 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 garnet sand and quartz sand arrive in dry condition; sieved to the requested grain size, 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 garnet sand and quartz sand 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 bais of the initial data the production technology consists of the main phasis as follows:

2.1 Receipt of garnet sand and quartz sand, and storage thereof
2.2 Receipt and storage of lime
2.3 Measuring of garnet sand, quartz sand and lime, mixing
2.4 Pressing the mixture into bricks
2.5 Storage of finished products or delivery

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

2.1 Receipt of garnet sand, quartz sand and storage thereof

The tipping ear car full with garnet sand and quartz sand pours its charge to one of the bunkers of 18 m^3 /10/ in the covered storage area.
From the covered bunker the garnet sand and quartz sand are picked up by a handspike front elevator and are 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 mixture to a rubber-textile

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

2.2 Receipt and storage of lime

The lime is delivered to the brick factory by tank car. The discharge resp. the pouring into the lime silo of 290 m^3 is made by a pneumatic conveyor being on the car. The filling capacity of lime silo is for 11 days' lime demand. From the big silo the lime powder is conveyed pneumatically according to the demand in smaller lime silos of 25 m^3 /13/ and from here by worm feeder /14/ to the lime scale /17/ tank in the mixing hall. The ratio of lime in the mixture has been 30 per cent.

2.3 Measuring garnet sand, quartz sand and lime, mixing

The puffer tank above the mud powder 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 scale /15/ has been 2000 kg.

The sand goes from the scale tank by gravity to the intensive reversed current rapid mixer /18/ under the scale. The lime goes to the lime measuring tank /17/ of 0,4 m^3 into the mixing hall by worm feeder.

The measuring capacity of the scale has been max. 400 kg. After finishing the measuring the lime 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 garnet sand, quartz sand and lime, dry mixing is made then after automatic water addition /16/ homogenization is the following step.

Max. filling charge of the pre-mixer:	2ooo+4oo+24oo kg
Operating charge of the pre-mixer:	2ooo 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 50 w.p.c. garnet sand, but it can also reach the 40 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.

2.4 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 5oo 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 1 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: 22,5m
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: 22,5m
Filling capacity: 16- pcs hardening car
Autoclave cycle time: 2,35hours

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 pcs autoclave, with 16 hardening carriage per autoclave. The filling time of the autoclave has been /in full length/ 5 h. Consequently, in each shift 1,6 pcs waiting tunnel equivalent hardening car get into the auto-clave. As one autclave and as per day 512 pcs 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.

2.5 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 crained 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.

2.6 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 lime-sand brick

3.1.2 Nominal capacity of the plant: 10.000.000 pcs brick

unit 15.ooo m3/y capacity

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:7,5hours p... 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: 228o

volume of 1 pc brick /m^3/: o,oo133 kg

1 m^3 per brick pc: 752 kg

weight of brick per pc: 2 kg

average volume weight kg/m^3: 15oo

press capacity m^3/h: 2,5

material demand ton per hour per press: 4,4

brick pc per hardening carriage: 593

hardening carriage pc per hour per press: 3,7

In the above calculations we started from the volume weight of the finished product of 15oo kg/m^3.

3.1.6 Yearly production data of the brick factory

In case of production of bricks of 22ox11ox55 mm the technical /nominal/ capacity:

10 000 000 pcs/year

15 000 m^3/year

2o 000 to/year

3.2 Material demand

The data relate to nominal production.

initial data of calculation

- dry garnet sand content: 50 wpc
- quartz sand content: 4o wpc
- lime content: 1o wpc

3.2.1 Specific material demand per m^3 brick

name	unit of measure	
garnet sand	kg/m^3	752
quartz sand	kg/m^3	6o2
lime	kg/m^3	15o
water /at mixing/	l/m^3	167
water /steam production/	l/m^3	500
water for technology		933
water total	l/m^3	16oo

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

name	unit of measure	hour	shift	working day	year
garnet sand	to	2,2	16,5	33	10.000
quartz sand	to	1,77	13	26	8.000
lime	to	0,44	3,33	6,66	2.000
water	m^3	5,3	40	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 mm

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/	173,6	1215,2	3645,6	1.276.ooo
electric energy /kWh/	195,8	1371,4	3113,2	1.44o.ooo

3.4. Required staff

Labour /handling/ 6 persons

autoclaves loadiing and unloading 4 persons

Mashine operator and finished product handling lo persons

Ironworker and electrician 2 persons

supervisor 1 person

engineer 1 person

manager 1 person

total: 25 persons

3.5. Storage capacity

3.5.1. Garnet sand: 231 tons

This quantity secures 7 days' requirement.

3.5.2. Quartz sand: 182 tons

This quantity secures 7 days' requirement.

3.5.3. Lime: 46,6 tons

This quantity secures 7 days' requirement.

3.8. Technological description of a suggested floor and wall tile factory with a capacity of 2 mill sq.m. tiles/year, calculated on the data of Messrs. DORST

TECHNICAL DATA

Product	: glazed and decorated tiles of the size 200 x 200 x 7.5 mm single fired
Capacity	: about 2.000.000 m²/year
Weight of fired tiles	: about 18 kg/m²
Body requirement net	: about 36.000 tons / year
Body requirement gross	: about 42.000 tons / year
Glaze requirement gross	: on average 1.2 kg/m² corresponding to about 2.500 t/year
Working days	: 360 days/year
Working time of equipment per day	: 3 shifts = 24 hours
Electricity	: 380 V, 50 cycles, 3 phases
Installed power for the complete factory	: assumed with abt. 1500 kW
Consumption of el. energy for the complete factory	: assumed with abt. 24.000 kWh/day

Peak load of el. energy	: assumed with abt. 1200 kW
Heating fuel	: producer gas, dry and clean with a content of sulphurous components of max. 0.2 Vol.%/Nm^3
Net calorific value of fuel assumed	: 1350 kcal/Nm^3 $\pm$ 10 %
Consumption of fuel	: abt. 273000 Nm^3/day $\pm$ 10 %
Water requirement	: abt. 80 m^3/day for body and glaze abt. 50 m^3/day for cooling presses (abt. 5 m^3/day in case of using water recooling plant) (abt. 10 m^3/day for washing the equipment and factory)
Compressed air	: abt. 15 - 20 Nm^3/min at 6 bar pressure

PROPOSED TECHNOLOGY

The various raw materials for the tile body composition, which is composed mainly by brown mud, a waste product which results from your aluminium 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.

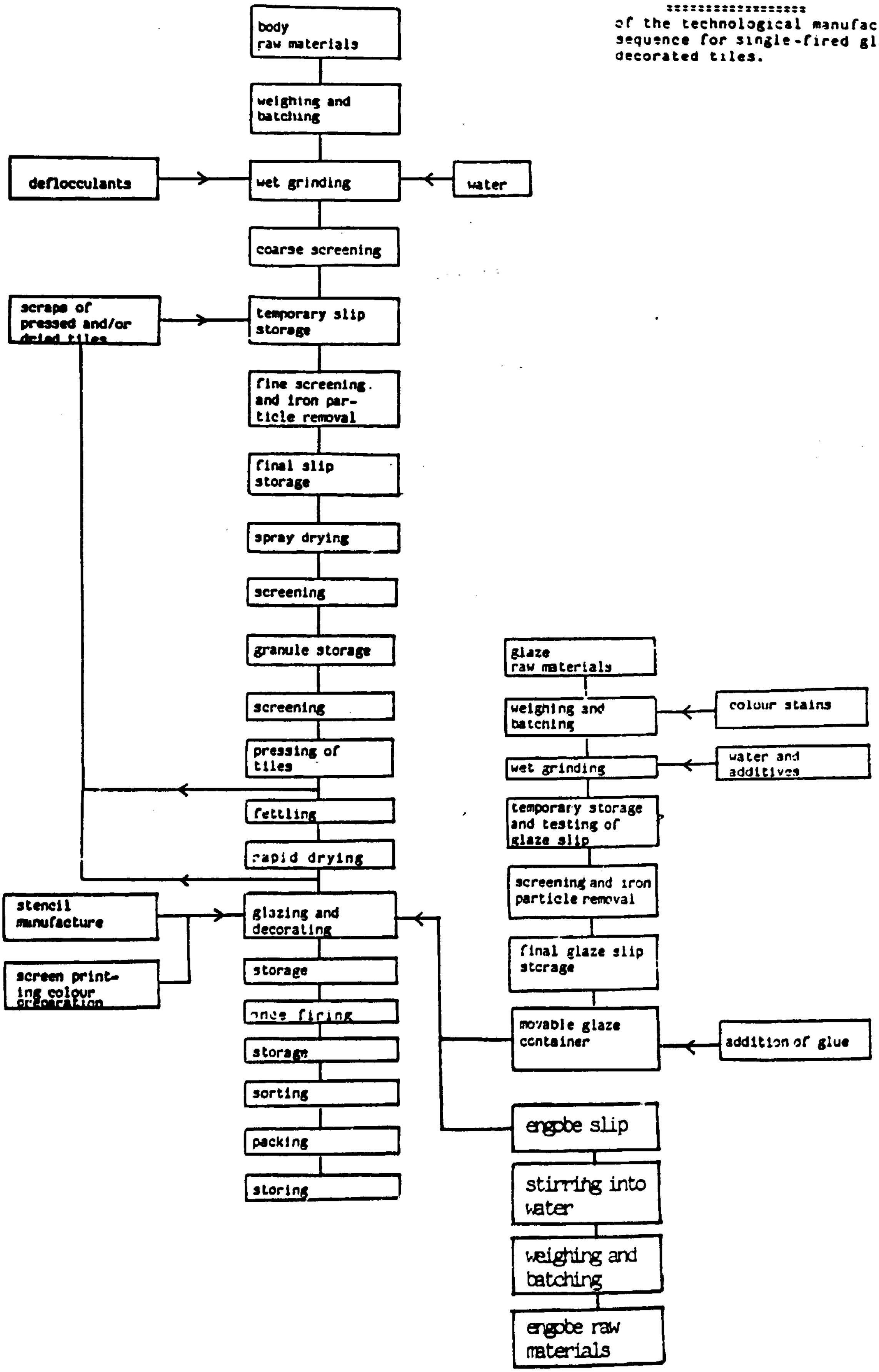
The glazed tiles stored in containers are transferred to the rapid firing roller kiln and fired in a single-layer tile carpet. After firing the tiles are restored in containers.

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.



3.9. Suggestion for the utilization of garnet for the glass industry

For the production of black glass and of architectural glasses made of garnet of 97 p.c. purity an already existing glass factory can be used by a minimal change in the equipment line.

For the melting of garnet due to its fine grain size the generally used cupola furnaces cannot be used. For this purpose tank furnace is to be built where in every square meter 1,2 o 1,6 t melt can be taken. This means in case of a tank of 2o m2, 1o-12.ooo tons of fibrous material.

A similar fritt furnace is necessary for the utilization of glasses marked by KM. /see table in chapter 3.6./ For this purpose an emailófritt furnace can be reconstructed by rebuilding of by-passing and feeder, resp. by building in a drop feeder. Costs can be regarded as a minimum.

The melting of numerated glass /see table in chapter 3.6./ types especially 81/S and 73/6 can be solved by a minimum rebuilt of the furnace. If it is not possible to rebuilt then special attention is to be given to the cooling of the different parts of the furnace.

The production of black glass does not require construction change of the furnace. From a surface unit 161,5 t glass can be produced per day, which means 4o-6o to/day glass production in case of unit-melter type furnace. Only those furnaces can be converted for the production of garnet based glass which produced previously almost the same product. For instance if the kiln produced previously hollow ware it cannot be used to produce rolled glass or "U" profile glass. In this case the whole line toghether with the furnace is to be changed.

The objective of the financial and economic evaluation in the present Study is to provide a predesign estimate about the profitability of the possible utilization of the OSCOM 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 OSCOM 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 and on unit cost information received from officers of OSCOM and other Indian sources. The wastes have not been costed. The plant site location is assumed to be OSCOM yard or close to it. Depreciation is calculated in a uniform manner to keep things uncomplicated at this stage.

Profitability 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. Glazed and decorated tiles for garnet sand based technology, /total investment cost/

Predesign estimate

Annual capacity 2 mill m2 single fired floor and wall tiles

	Rs. thousand	Rs.
A. Site, buildings, etc.		
1. Land to be available by Messrs. IRE OSCOM		
2. Raw materials storage area 1ooo squ. Rs. 15o/sqm	15o	
3. Plant building, complete with lightind and utility connections 1o.ooo squm. Rs. 15oo/sqm.	15.ooo	
4. S u b t o t a l		15.15o.ooo
B. Machines and equipment		
5. Plant machinery	1oo.ooo	
6. Kiln	18.75o	
7. S u b t o t a l		118.75o.ooo

C. Other pre-production capital costs

8. Engineering	850	
9. Ceramic know-how	2500	
1o.Technical assistance, supervision	500	
11. Contingency, 1o% of item A+B	13390	
12. Working capital, 2o % of annual sales /of Rs.2oo.ooo.ooo/	40000	
13. S u b t o t a l		57.240.000
Total Capital Requirement		191.140.000

4.1.1. Glazed and decorated single fired floor and wall tiles

Predesign Production Cost Estimate

Product weight: 2o kg/m2

Product size: 2oox2oox7,5 mm
2oox3oox7,5 mm

	Rs.	Rs.
A. Raw material		
1. Garnet sand - 3o.ooo tons - Rs. 9oo/t	27.000.000.	
2. Clay - 2o.ooo tons Rs. 2o/t /mined royalty, cost of digging, tansport cost incl.loading/		
3. S u b t o t a l		27.4oo.ooo
B.Utilities		
4. Glaze, 26oo t Rs. 12.5oo/t	32.5oo.ooo	
5. Heating fuel light fuel oil 15.ooo t Rs 288o/t	43.2oo.ooo	
6. Power, 7.5oo.ooo kWh Rs. o,5/kWh	3.75o.ooo	
7. Water 45 ooo cu.m., Rs 1/cum.	45.ooo	
8. S u b t o t a l		79.495.ooo

C. Labour required - 2oo persons -

9.Rs. 9oo a month/pers.	2.16o.ooo	2.16o.ooo
D. Miscellaneous		
1o. Maintenance and repair		
2 % of building cost	3o3.ooo	
5% of equipment cost	5.ooo.ooo	
2% of kiln cost	375.ooo	
11.Insurance and other cost		
1% of total investment	1.911.4oo	
12. Depreciation		
3 % of building cost	454.5oo	
5 % of kiln cost	937.5oo	
7 % of equipment cost	7.ooo.ooo	
13. Overhead /administrative and selling/ 7 % of annual sales	14.ooo.ooo.	
14. Interest		
12 % on 5o % of loan /Rs.1oo.ooo.ooo/	12.ooo.ooo	
15.. S u b t o t a l		41.981.4oo
16. T o t a l annual cost of operation		151.o36.4oo

4.1.2. Glazed and decorated tiles

Profitability

1. Gross annual revenue from sales if 2.ooo.ooo squ.m. glazed and decorated single fired floor and wall tiles are sold at Rs. 1oo/sqm. /ex works/	2oo.ooo.ooo	
2. Annual cost of operation /see item 16 of 4.1.1./	151.o36.4oo	
3. Annual goss profit		48.963.6oo
4. Rate of return of capital outlay /excluding loan/	$\frac{\text{Rs. } 48.963.6oo}{\text{Rs. } 1oo.ooo.ooo}$ xx 1oo %=49 %	
5. Pay back period		2 years

4.1.3. Glazed and decorated tiles

Cash flow at Rs.1oo/sq.m.

1. Gross profit /see item 3 of 4.1.2./	Rs. 48.963.6oo
2. Depreciation /see item 12 of 4.1.1./	8.392.ooo
3. Annual repayment of loan princiapal of Rs. 1oo.ooo.ooo in 7 years	14.ooo.ooo
4. Net cash flow /1.+2. - 3./ in any one production year	43.355.6oo

4.2. Walling bricks

Total investm nt cost

Predesign Estimate

Annual capacity: lo mill standard bricks for garnet sand based cold technology

	Rs. thousand	rs.
A. Site, buildings, etc.		
1. Land to be available by Messrs. IRE OSCOM		
2. Raw materials storage area looo squm. Rs. 15o/sqm.	15o	
3. Plant building, complete with lighting and utility connections 5oo sqm Rs. 15oo/sqm	75o	
4. S u b t o t a l		9oo.ooo
B. Machines and equipment		
5. Plant machinery	4.ooo	
6. Autoclave	3.ooo	
7. S u b t o t a l		7.ooo.ooo

C. Other pre-production capital costs

8. Engineering	1oo	
9. Know how	4oo	
1o.Contingency, 1o % of item A B	79o	
11. Working capital, 2o % of annual sales /of Rs.4.5oo.ooo/	9oo	
12. S u b t o t a l		2.19o.ooo
Total capital requiirement		1o.o9o.ooo

4.2.1. Walling bricks

Predesign Production Cost Estimate

Product weight 2 kg/pc

Product size 22ox11ox55 mm

	Rs.	Rs.
A. Raw materials		
1. Garnet sand 11.ooo t		
Rs. 1o/t	11o.ooo	
2. Quartz sand 8.8oo t		
Rs. 1o/t	88.ooo	
3. Lime - dry CaO - 2.2oo t		
Rs 5oo/t	1.1oo.ooo	
4. S u b t o t a l		1.298.ooo
B. Utilities		
5. Fuel - coal 45o t /52oo kcal/kg/		
Rs. 25o/t	112.5oo	
6. Power , 225 ooo kWh		
Rs.o,5 / kWh	112.5oo	
7. Water 24 ooo cu.m.		
Rs 1/cu.m.	24.ooo	
8. S u b t o t a l		249.ooo

C. Labour and supervision

9. Labour /handling/		
6 persons - Rs 5oo a month/pers	36.ooo	
1o. Autoclave loading and unloading		
4 persons - Rs. 6oo a month/pers	28.8oo	
11. Machine operators & finished product handling 1o persons - Rs.8oo a month/pers.	96.ooo	
12.Ironworker & electrician		
Rs 9oo a month/pers. 2 persons	21.6oo	
13.Supervisor 1 person Rs.15oo a month	18.ooo	
14. Engineer 1 person Rs 16oo a month	19.2oo	
15. Manager 1 person Rs 2ooo a month	24.ooo	
16. S u b t o t a l		243.6oo

D. Miscellaneous	Rs.	Rs.
18. Maintenance and repair		
2% of building cost	18.000	
5% of equipment cost	2oo.coo	
2% of autoclave cost	6o.ooo	
18. Insurance and other costs		
1% of total investment	1oo.ooo	
19. Depreciation		
3% of building cost	27.000	
5% of autoclave cost	15o.0000	
7% of equipment cost	28o.000	
2o. Overhead /administrative and selling/ 7% of annual sales	315.000	
21.Interest		
12% on 5o % of loan /rs. 5.000.000/	300.000	
22. S u b t o t a l		1.45o.000
23. T o t a l annual cost of operation		3.24o.000

4.2.2. Walling bricks

Profitability

	Rs.	Rs.
1. Gross annual revenue from sales if lo mill standard bricks are sold at Rs.45o/1ooo bricks ex works	4.5oo.ooo	
2. Annual cost of operation /see item 23 of 4.2.1.D./	3.24o.ooo	
3. Annual gross profit		1.26o.ooo

4. Rate of return of capital outlay

/excluding loan/ $\frac{\text{Rs. } 1.26\text{o.ooo}}{\text{Rs. } 5.\text{ooo.ooo}}$ x 1oo %= 25,2 %

5. Pay back period 3,97 years

4.2.3. Walling bricks

Cash flow at Rs 45o/1ooo bricks

1. Gross profit /see item 3 of 4.2.2./	Rs. 1.26o.ooo
2. Depreciation /see item 19 of 4.2.1.D./	457.ooo
3. Annual repayment of loan principal of Rs.5.ooo.ooo in 7 years	7oo.ooo
4. Net cash flow /1+2-3/ in any one production year	1.o17.ooo

Chapter Four

Financial and Economic Evaluation

4.1. Glazed and decorated tiles, total investment cost

- 4.1.1. Predesign Production Cost Estimate
- 4.1.2. Profitability
- 4.1.3. Cash flow

4.2. Walling bricks , total investment cost

- 4.2.1. Predesign Production Cost Estimate
- 4.2.2. Profitability
- 4.2.3. Cash flow

Chapter Five

Market Survey of Selected Building Materials

Contents

Annexures

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	25.5	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 Erick 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

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[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 supply of these bricks is expected to increase from the present level of about 40,000 million to nearly 85,000 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	All-India Hand Moulded	All-India 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	85,060

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 un-organized 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 2.5

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 usnkilled 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: NECC 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 1985–86 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.o
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/

	All-India		
Year	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 NBOC 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	156	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 12¼" to 13¾". They are suitable for laying both straight and breaking joints.

d <u>Taylor Tiles:</u> These are smaller tiles with an overall length of 11¼". 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 <u>Ridge Tiles:</u> 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 <u>Taylor Ridges:</u> These are used along with Taylor tiles and are semi-circular in shape. 18¼" in length, 260 ridges are required for 100 running metres. Their bulk volume is 4 cubic metres.

g <u>Ceiling Tiles:</u> 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	28
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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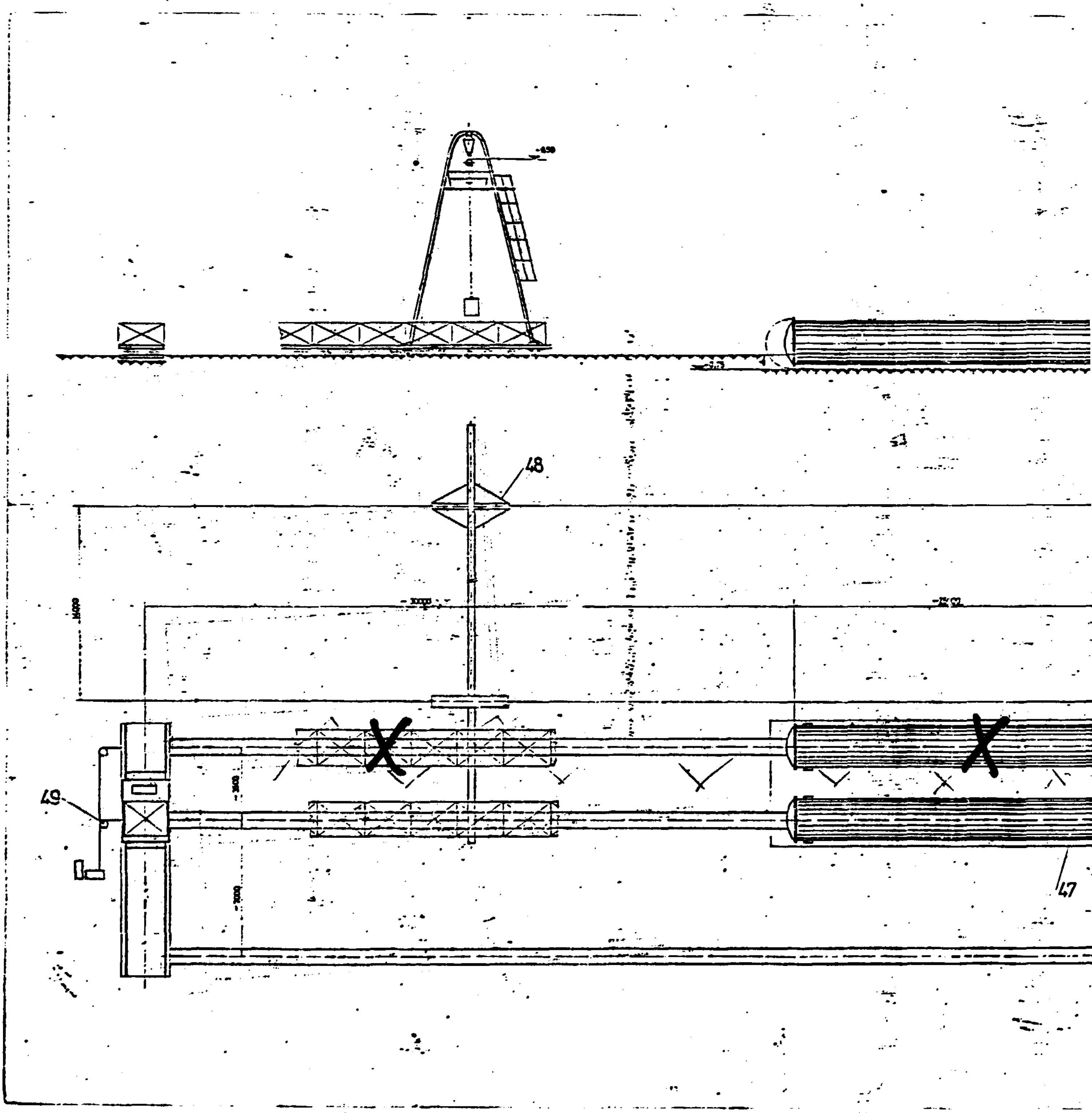

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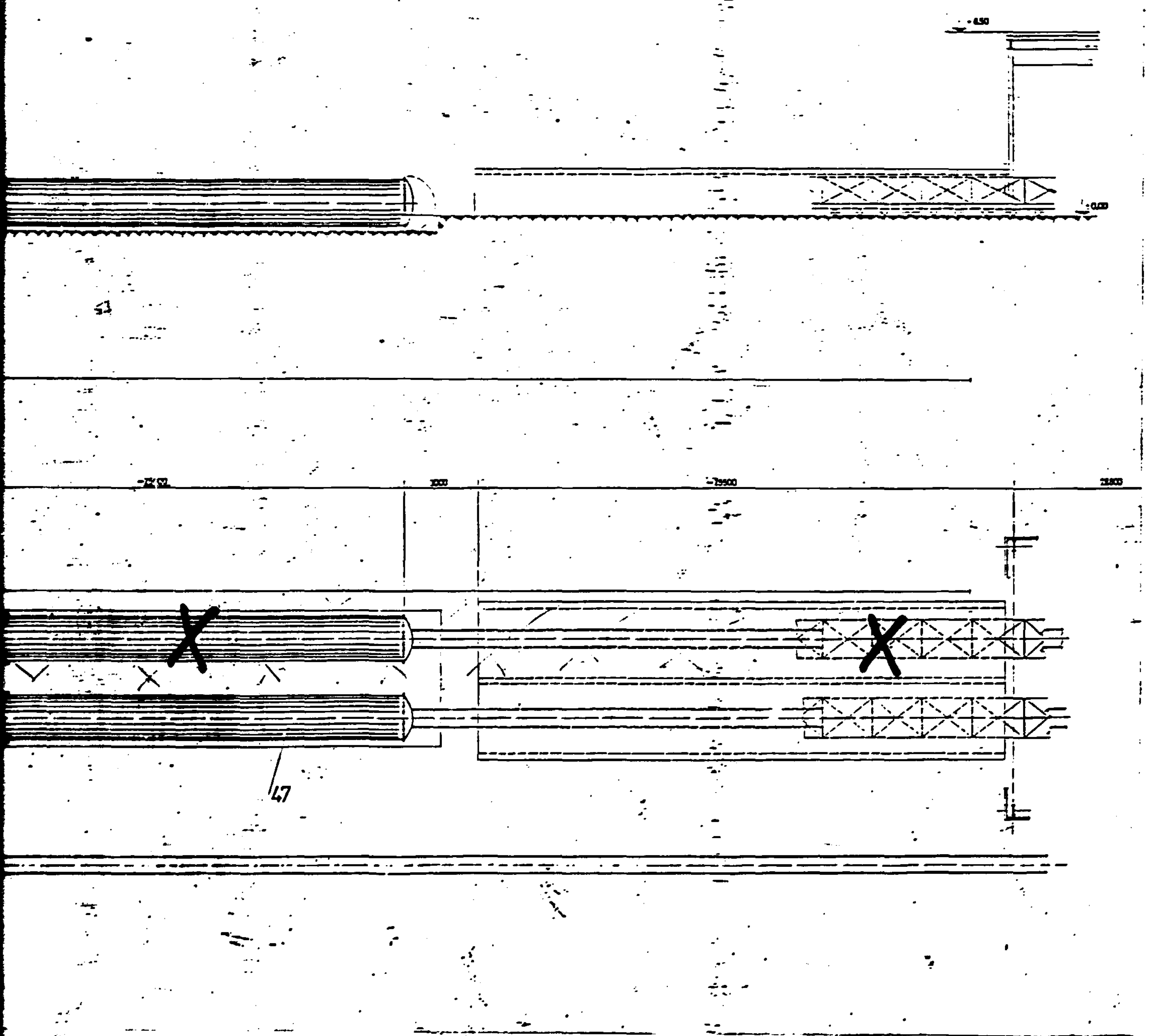

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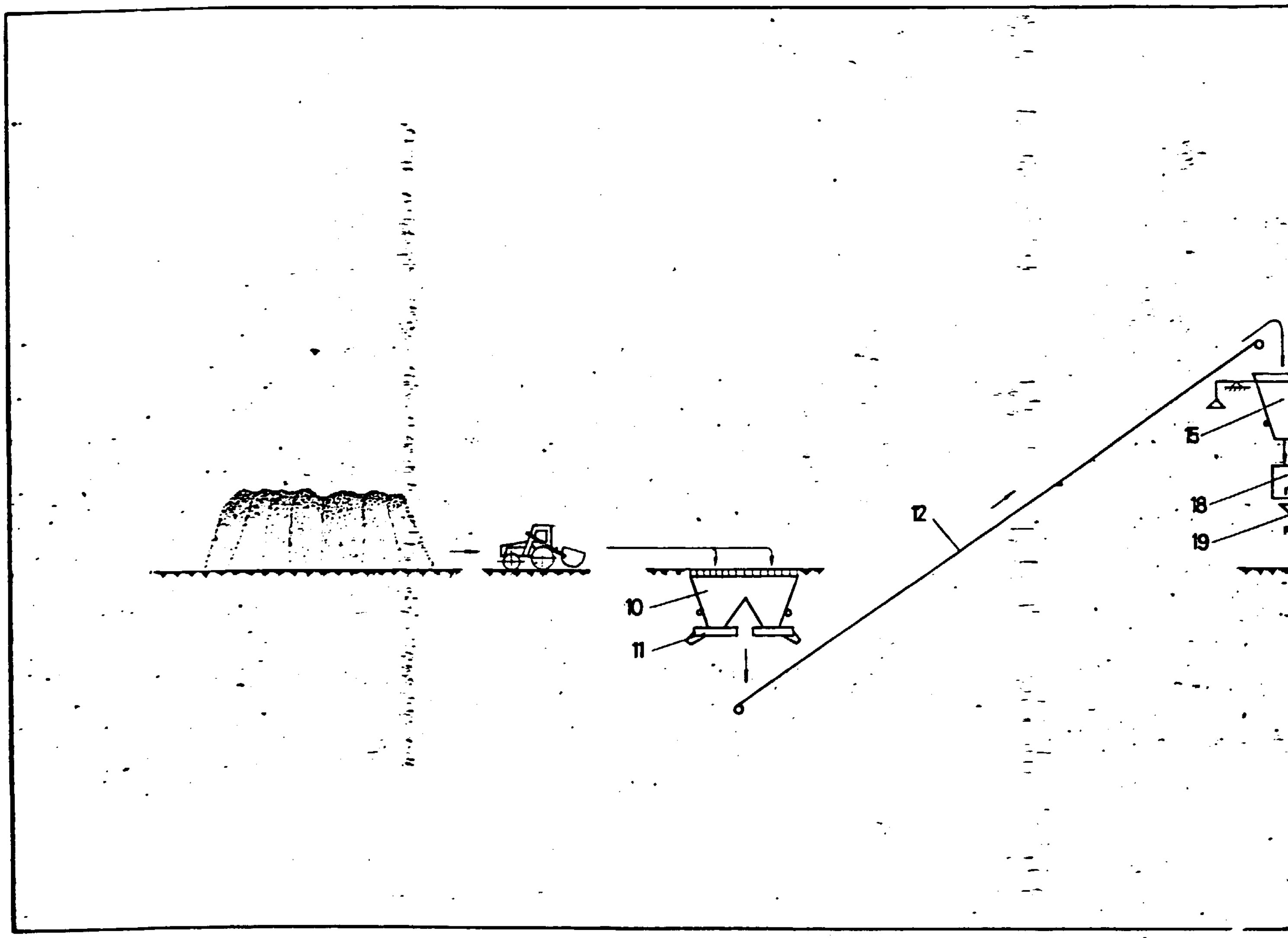

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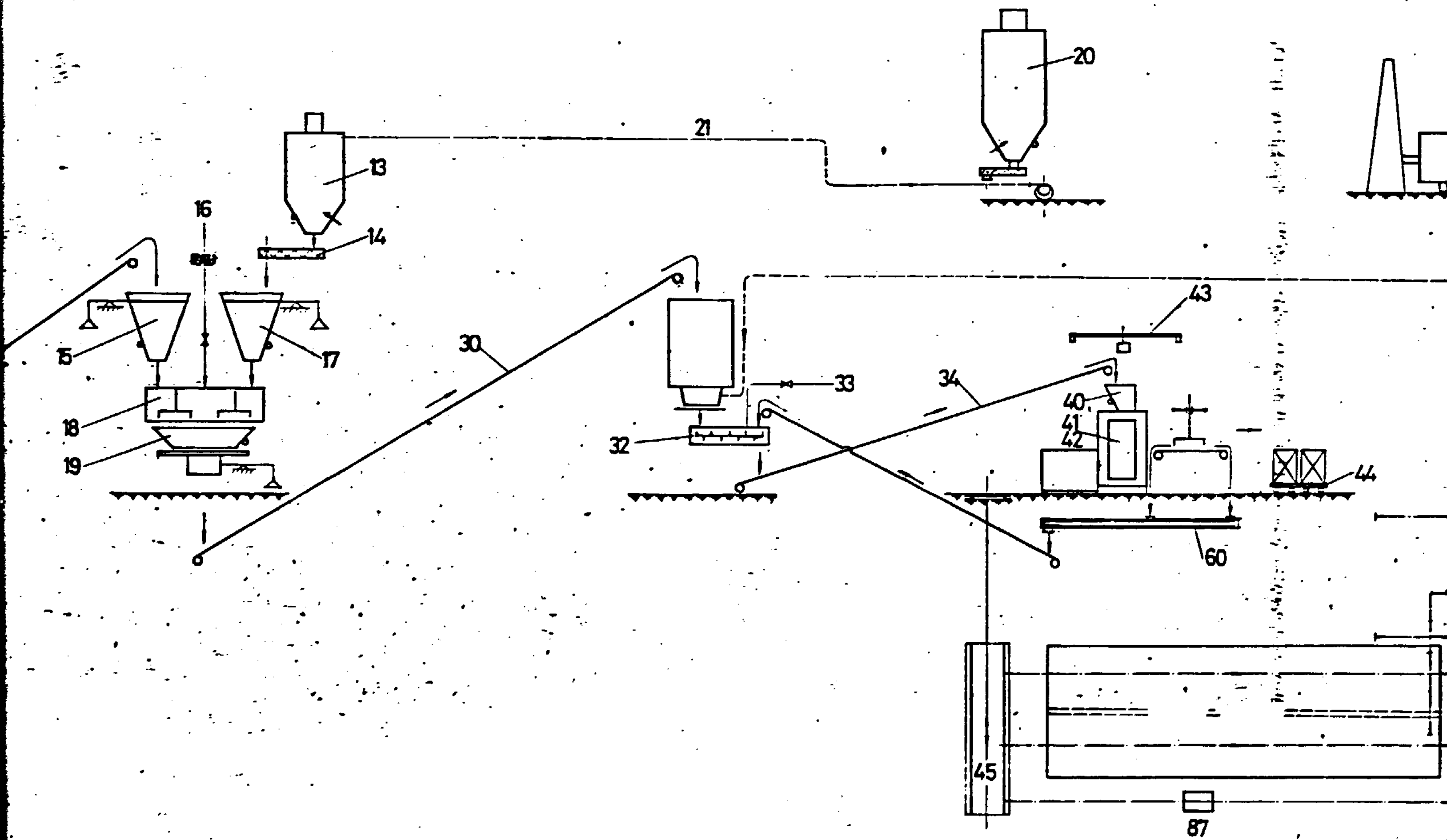

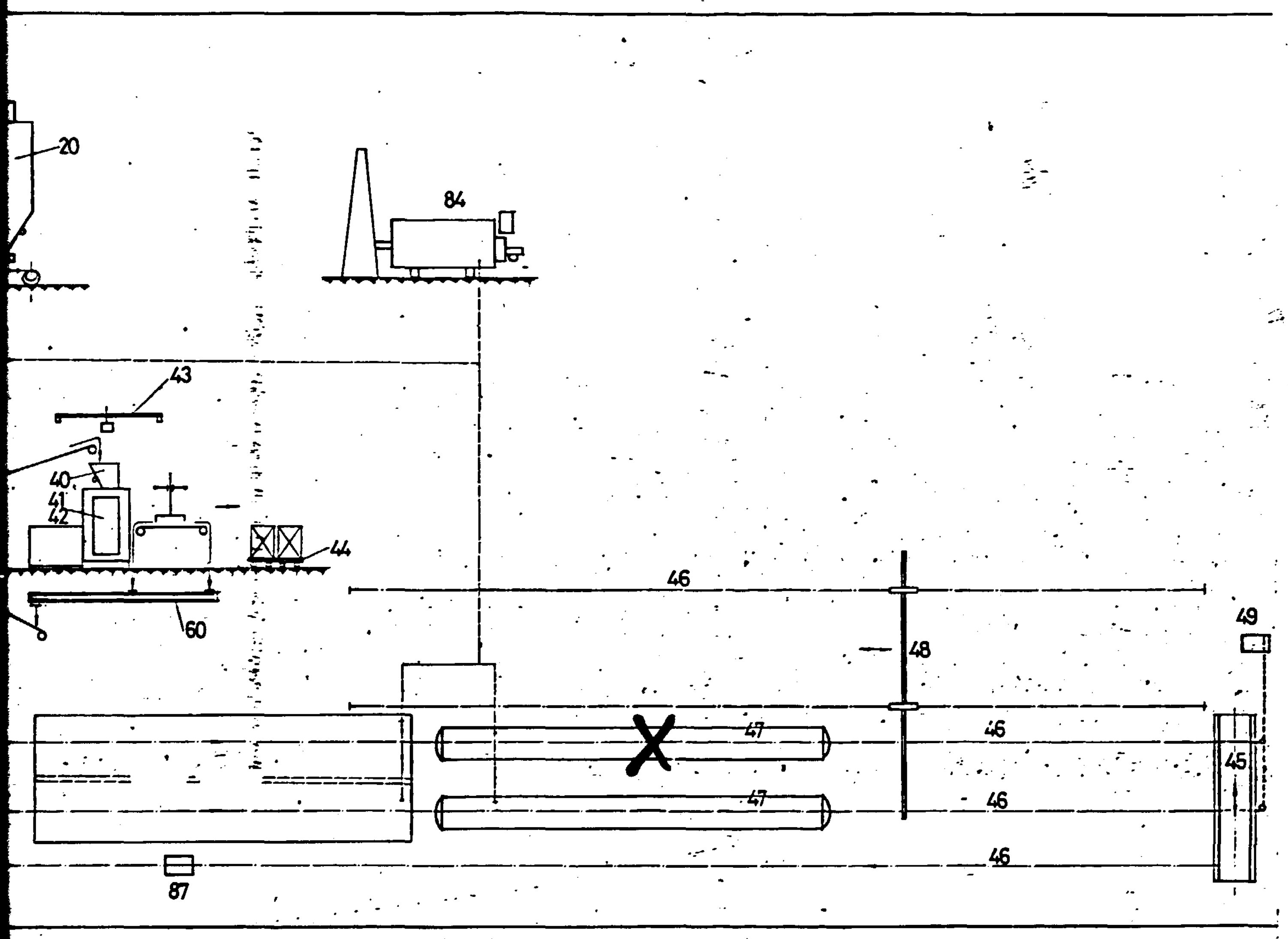

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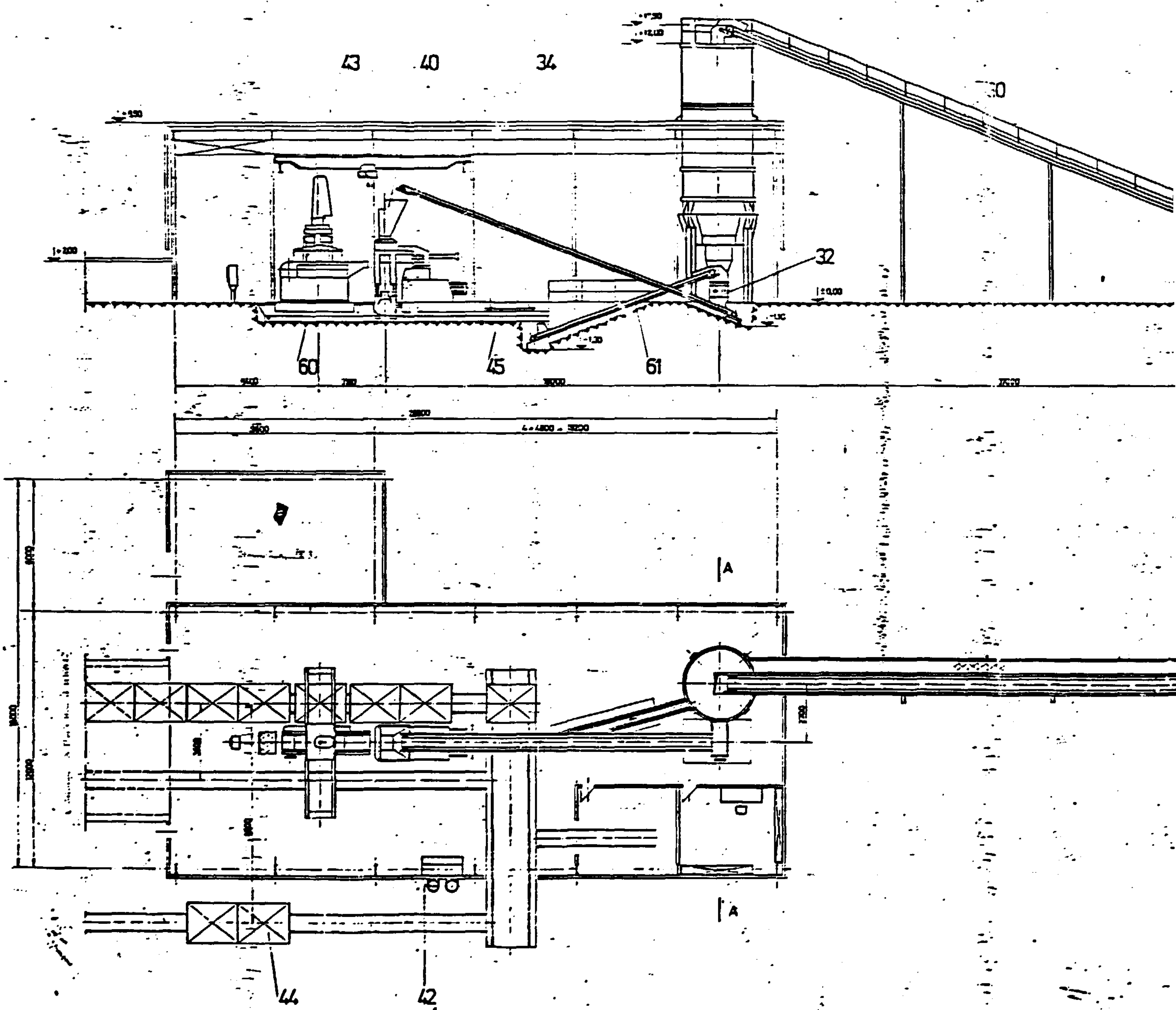

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