MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

Kazakh National Research Technical University named after K.I.Satbayev

Institute of Architecture, construction and energetics named after T.K.Bassenov

Department "Construction and construction materials"

Qamıt Dáýlet Batyrbekuly

"The plant of the production of low water demand binders in city Shymkent with a capacity of 60 tons per day"

EXPLANATORY NOTE

to the final thesis

Specialty 5B073000 – Production of building materials, products and structures

Almaty 2019

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APPROVED
Head of the department "Construction and construction materials"
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"___" _________ 2019

THE TASK
to complete the final thesis

Teaching student: *Qamıt Dáýlet Batyrbekuly*
Topic: *The plant of the production of low water demand binders in city Shymkent with a capacity of 60 tons per day*
Approved *by order of the Rector of the University №___ dated "__" ______2019 y.*
Deadline for completed work: *"___" _________ 2019 y.*
Baseline data to work: *The plant of the production of low water demand binders in city Shymkent with a capacity of 60 tons per day*
The list of questions to be developed in the thesis project:
a) *technological part*
b) *heat engineering part*
c) *architectural and construction part*
d) *economic part*

The list of graphic material: general plan of the enterprise, plans and sections of the main production departments of the enterprise, the technological scheme of production, technological map of the product, technical and economic indicators of the plant
List of graphic material: ____ *slides of the work presentation are presented*
Recommended main literature:
1. Zozuli P. V., Nikiforova Yu. V., Design of cement plants; 2011.
2. Bolotskikh O., European methods of physical and mechanical testing of cement, Kharkiv – Moscow, 2015 - 948 c.
3. Roach S. M., Roach G. S., Special cements; Moscow, 2014 - 280 c.

АҢДАТПА

Бұл дипломдық жобаның мақсаты Шымкент қаласында қуаты тәулігіне 60 тонна төмен су тұтыну байланыстырғыш бойынша зауытты жобалау.

Жобалау кезінде технологиялық және жылутехникалық есептеулер орындалды, бас жоспар негіздері көрсетілді, негізгі және қосалқы нысандарды орналастыру бойынша шешімдер қабылданды, негізгі техникалық-экономикалық көрсеткіштер есептелді.

Дипломдық жоба 40 бетте жазылған, 28 кест, 4 сурет, 4 қосымша, 27 әдебиет көзі бар.

Түйінді сөздер: төмен су тұтыну байланыстырғышы, портландцемент, клинкер, технология, өндіріс.

АННОТАЦИЯ

Целью данного дипломного проекта является проектирование завода по производству вяжущих низкой водопотребности в городе Шымкент мощностью в 60 тонн в сутки.

При проектировании выполнены технологический и теплотехнический расчеты, представлены обоснования по генеральному плану, произведена компоновка основных и вспомогательных объектов, расчитаны основные технико-экономические показатели.

Дипломный проект изложен на 40 листах, включает 28 таблиц, 4 рисунка, 4 приложения, 27 литературных источников.

Ключевые слова: вяжущее низкой водопотребности, портландцемент, клинкер, технология, производство.

ABSTRACT

The purpose of this diploma project is to design a plant for the production of low water demand binders in the city of Shymkent with a capacity of 60 tons per day.

When designing, technological and thermal calculations were performed, justifications of general plan are showed, the layout of the main and auxiliary facilities was made, the main technical and economic indicators were calculated.

The diploma project is presented on 40 sheets, includes 28 tables, 4 figures, 4 appendices, 27 literature sources.

Key words: binder of low water demand, Portland cement, clinker, technology, production.

CONTENT

INTRODUCTION

In the construction of buildings and structures of the industrial and civil sector, concrete and reinforced concrete are still used. With the use of LWDB it is possible to obtain particularly strong light and heavy concretes, but an important role belongs to the nature, strength, density and geometric shape of coarse aggregates. If on the basis of crushed expanded clay gravel, the maximum achieved strength of normal hardening concrete at the age of 28 days at a consumption of LWDB 480 $kgpm^3$ is about 60 MPa at a volume weight of 1750 $kgpm^3$, then the use of high-strength and dense gabbro in the main cubic form allows to obtain concrete from mobile mixtures (CS=4-6 cm) with a strength of more than 150 MPa. Further strength gain is limited by the strength of the coarse aggregate [1].

The use of LWDB-100 is promising for high-strength concrete of classes B45 and above, while 35-50% of the clinker part of the cement can be saved. It is suitable for non-welded reinforced concrete technology. LWDB-50 prospectively in the concrete of classes B30-B45 and can be used in concrete class B25.Thus saving of clinker part of cement of 50 % and more is reached, term and temperature of heat treatment are considerably reduced, and in many cases necessity in heat and humidity processing of these concretes disappears.

The use of concrete on LWDB expands the area of non-heated concreting in winter conditions. The temperature of hardening of fine-grained concrete on LWDB to minus 10°C depends on the fineness of the binder grinding and with an increase in the specific surface area from 500 to 700 mg/kg compressive strength at the age of 28 days increases from 9 to 28.5 MPa at a temperature of minus 10°C and from 13.8 to 43.5 MPa at minus 5°C. Concrete, stayed for 28 days at minus 10°C and with subsequent aging for 28 days under normal conditions, reaches 70-80 % of the design strength.

The purpose of this diploma project is to develop a company for the production of binders of low water demand in Shymkent, with a capacity of 60 tons per day, based on Portland cement conventional industrial fineness of grinding, using effective chemical and mineral additives that can significantly reduce water demand and accelerate the hydration of the binder in the manufacture of concrete mixture.

Application of LWDB allows to increase potentially real activity of cement in 2-2,8 times, and respectively, durability of concrete in 1,5-2 times. Further strength improvement is limited by the properties and characteristics of the aggregates. It is clear that this increase in strength can be realized in the form of significant technological advantages.

The potential opportunities for increasing the strength of concrete can be converted into a variety of exceeded its other characteristics and especially its technological properties.

1 Technologicalpart

1.1 Marketing analysis of cement and concrete market

Analysts sum up the preliminary results of the development of individual segments of the market of building materials. Traditionally, the most important indicators include the dynamics of production and prices of cement and concrete. Cement production in September 2018 increased by 11.7% compared to September 2017, but decreased compared to August 2018 to 7.8% to 5.4 million tons. Production since the beginning of 2018 increased by 11.6% compared to the corresponding period of 2017 and amounted to 38.3 million tonnes.

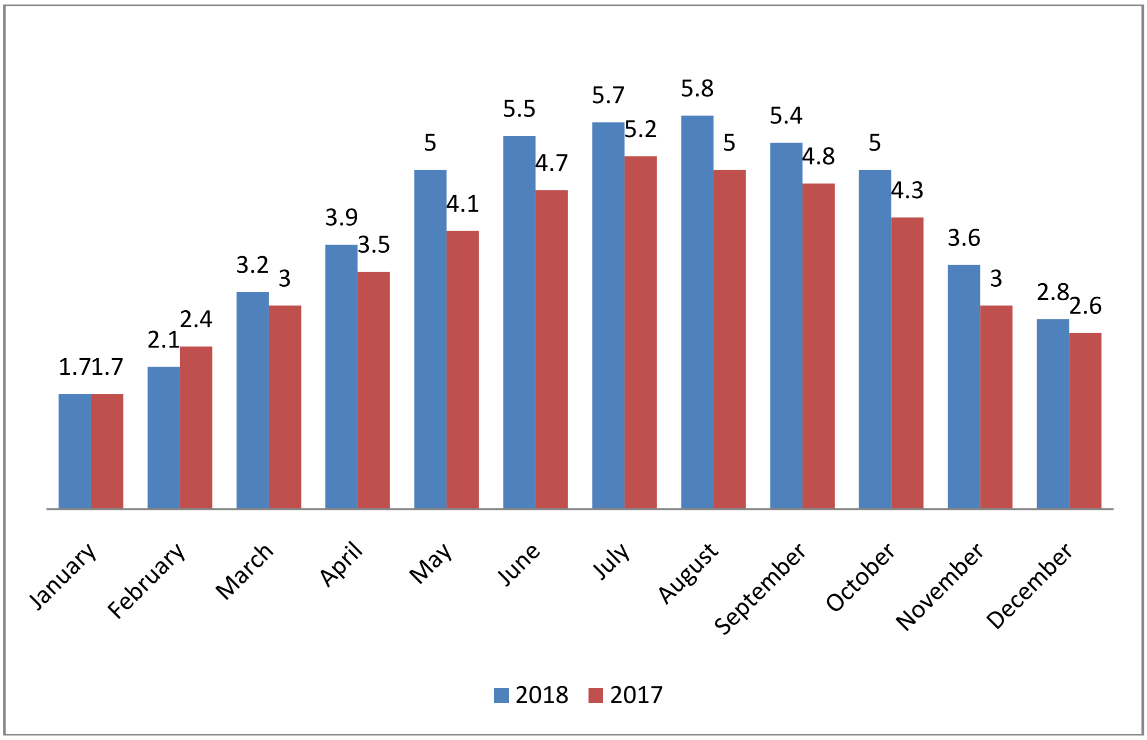


Figure 1 – Graph of cement production, million tones

Despite the seasonal decline in production, the average price of cement continued to move up and reached 21,653. 8 tg/t of cement (manufacturer’s price without VAT and delivery) — probably the final attempt of producers to get the maximum profit from the sale of products in the outgoing construction season. In the first nine months of 2018, the average price of cement is 20 137 tg/t (manufacturer’s price without VAT and delivery).

Previously made predictions for 2018 remain relevant: the average annual price of cement is not more than 20175.2 tg/t, production volume — about 50 million tons of cement. The production of premixed concrete in September 2018 declined by 1.9% compared to September 2017 and amounted to 2.2 million cubic meters in January — September 2018 to 4.8% to the corresponding period 2017 to 14.1 million cubic meters, the Average monthly price (manufacturer's price excluding VAT and delivery) continued to increase and reached 27157,9 tg/m^3 (+3% compared to August 2018).

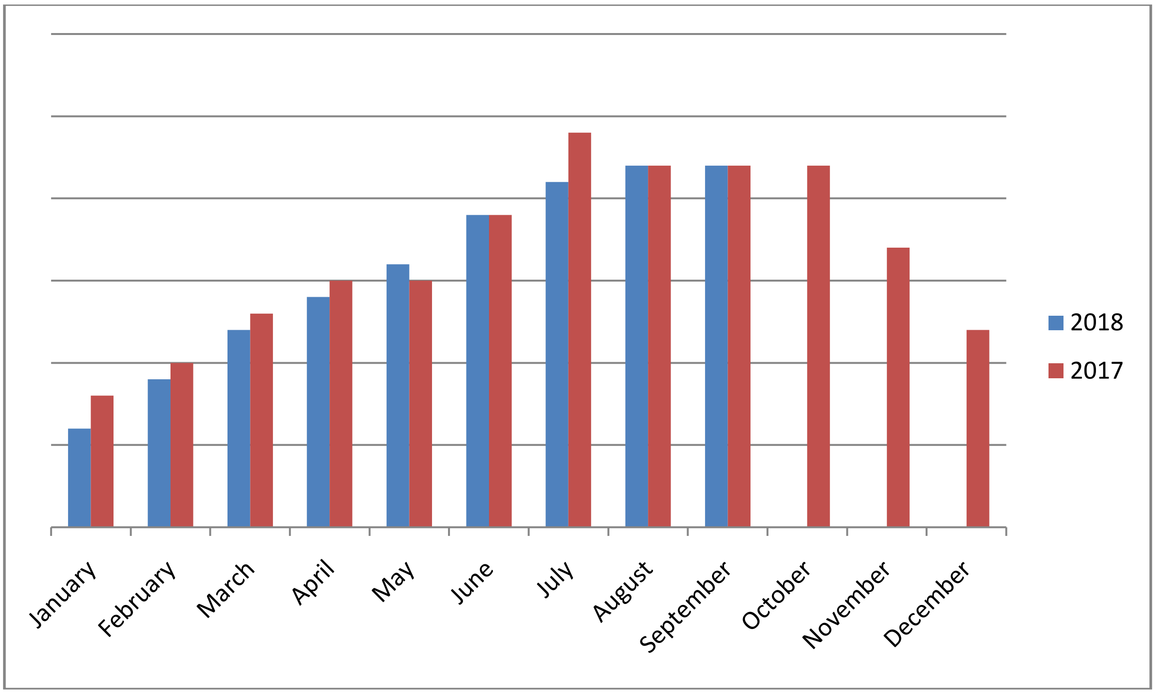


Figure 2 – Graph of production of premixed concrete, million cubic meters

1.2 Technical and commercial characteristics of the products

Binders of low water demand by material composition are divided into the following types:

- LWDB;
- LWDB with mineral additives.

By mechanical strength binders are divided into brands:

- LWDB – 600, 700, 800, 900, 1000;
- LWDB with mineral additives – 300, 400, 500, 600, 700, 800.

According to the ratio of the components of the binder are divided into brands:

- LWDB – 30, 50, 70,100.

The projected plant for the production of binders of low water demand in the city of Shymkent, with a capacity of 60 tons per day, will produce LWDB-70.

The fineness of the grinding binders should be such that when sifting the sample through a sieve with a mesh № 008 according to [12], at least 95% of the mass of the sifted sample passes, and for LWDB with mineral additives - at least 90%.

Initial setting time of the mixture must occur not earlier than 45 min, and end no later than 10 hours [1].

Indicators characterizing the technical and technological properties of binders should not be worse than similar indicators for portland-cement, given in [12].

The shelf life of binders before their use may be limited to 15 days.

Mechanochemical treatment allows to strengthen the useful properties of the components of the complex binder: the strength of cement increases by 2-3 grades, and the plasticizing effect of the organic component of the modifier increases approximately twice. In practice, this leads to a decrease in the water content of concrete mixtures isolating to 120-135 l/m^3 and W/C to 0.25-0.30 for moving mixtures and to 0.20-0.25 for hard [1].

Along with this, the efficiency of the use of LWDB is due to a decrease in the consumption of the binder in the manufacture of 1 m^3 of equal-strength concrete: the index of using of the binder according to industrial testing is 1.7-2.4 for heavy concrete and 1.3-1.4 - for fine-grained concrete (the index of using of theportland-cement is 0.6-0.9, i.e. each kilogram of consumption of theportland-cement corresponds to 0.06-0.09 MPa of concrete strength) [1].

The quality of concrete on mineral binders must meet the requirements to [13], [14], [15] and ensure the manufacture of products and structures that meet the requirements of GoSt and project documentation.

1.3 Characteristics of raw materials and additional materials

Limestone deposit

Sastobe limestone deposit is located in the Tulkubas district. Chemical composition of limestone from Sastobe deposit is shown in table 1.

Table 1 – Chemical composition of Sastobe deposit's limestone

Content of oxides, % by the weight							
SiO_2	Al_2O_3	CaO	MgO	MnO	TiO_2	Fe_2O_3	the p.o.i
0,02-1,4	0,01-1,8	50,1-55,5	0,1-2,8	0,005-0,01	0,007-0,02	до 0,73	39,31-43,7

The Content Of CaO-78-94%, MgO - 5-8%.

Table 2 – The properties of Sastobe deposit's limestone

Parameter	Unit	Value
Bulk density	g/cm^3	2,55
Density	g/cm^3	2,7
Water absorption	%	2,5
Specific weight	g/cm^3	1,62
Volumetric-bulk weight	kg/m^3	1300
Porosity	%	0.6
The content of clay particles	%	1
Moisture content	%	0.1

Limestones consist of 98% of calcite, in an amount of about 2 chalcedony, quartz, less dolomite and the remains of microorganisms are noted. Limestone reserves of Sastobe deposit by categories A+B+ is about 70 million tons.

Clay and loam Deposit

Badam loam deposit(Panfilov area) is located in the Bogen dictrict, 4 km notheast of the station Badam Almaty railway and 25-30 km from Shymkent city. Explored in 1960 by George University of facturing and reconnoitered in 1980 in the Panfilov farm area.

The Deposit composed of middle Quaternary loams of the fourth above-floodplain terraces of the river Badam,is presented by a tabular Deposit in the size of 1100x400 m, with a capacity of 3.8-14.7 m. The thick capping is a soil-plant layer with a capacity of 0.4 m.

Table 3 – The chemical composition of Badam deposit's loam

Content of oxides, % by the weight									
SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	SO_3	the p.o.i
53,21	10,77	4,24	0,60	11,68	2,42	2,16	1,66	0,52	11,44

Table 4 – The properties of Sastobe deposit's limestone

Parameter	Unit	Value
Bulk density	t/m^3	1.57
The number of plasticity	quantity	5,24
Optimal firing temperature	°C	1050-1100
Shrinkage: - air - a total	%	 2,61-3,2 2.07-2,70
Water absorption	%	20,10-21,87
Tensile strength - compression - bending	kg/cm^2	 118-155 23-36
The index of sensitivity to drying	-	0,36
Frost mark	F	25,30,35

Loam is suitable for the manufacture of brick grades 100 and 125 with F25 and F35, meets the requirements to [16].

PC clinker[6]

The chemical composition of PC clinker. PC clinker is usually obtained in the form of sintered small and larger granules and pieces up to 10 – 20 or 50 – 60 mm depending on the type of furnace.

The chemical composition of clinker varies within a relatively wide range. The main oxides of cement clinker are calcium oxide CaO, silicon dioxide SiO_2, aluminum oxides Al_2O_3, iron Fe_2O_3, the total content of which is 95 – 97%. Besides them, the composition of the clinker in the form of different compounds in small quantities can include oxides of magnesium MgO sulfuric anhydride SO_3, titanium dioxide TiO_2, chromium oxide Cr_2O_3, Mn_2O_3 manganese, alkalis Na_2O and K_2O, phosphoric anhydride P_2O_5 and etc. The Content of these oxides in clinker is in the range specified in table 5.

Table 5 – The content of oxides in the clinker[10]

The content of oxides in the clinker, % by the weight								
CaO	SiO_2	Al_2O_3	Fe_2O_3	MgO	SO_3	$Na_2O + K_2O$	$TiO_2 + Cr_2O_3$	P_2O_5
63 – 66	21 – 24	4 – 8	2 – 4	0,5 – 5	<1	0,4 – 1	0,2 – 0,5	0,1 – 0,3

In the analysis of clinker, determine not only the total number of individual oxides, but also the degree of binding of CaO and SiO_2, i.e. learn how much CaO and SiO_2 remained in the free state.

Mineralogical composition of clinker[5]

The main phases of portland-cement clinker are alite (C3S), belite (C2S), tricalcium aluminate (C3A) and four-calcium aluminoferrite (C4AF).

The main minerals of cement clinker are alite, 3CaO*SiO or C3S and belite $2CaO*SiO_2$ or C2S.

Alite is the most important clinker mineral-silicate, which determines high strength, fast hardening and a number of other properties of portland-cement. In clinker, it is usually found in an amount of 45-60%.

The maximum rate of decomposition of pure mineral is observed at 1100 °C, and mineral with additives — at 1200 °C. Partial decomposition of C3S occurs in cement clinker. In this case, there are free valence bonds and there are additional vacancies in the lattice, which increases the hydraulic activity.

Alite is the main carrier of strength. It seizes within a few hours and increases strength relatively quickly. It is established that monoclinic alite hydrates faster, and triclinic acquires a higher strength in the later stages of hardening.

Belite is the second main mineral of PC clinker , characterized by slow hardening, but provides high strength during prolonged hardening of portland-cement.

Belit, as alit, is a solid solution of β-dicalcium silicate (β-$2CaO*SiO_2$) and small amounts (1-3%) of impurities such as Al_2O_3, Fe_2O_3, Cr_2O_3. It is contained in conventional PC clinkers in the amount of 15-30 % and is indicated by the formula β-C2S.

Belite does not have a certain setting time and solidifies very slowly when closed with water. Depending on the presence of certain impurities hydraulic activity of belite varies widely. According to Japanese researchers, the strength of the α -form is about three times higher than the strength of the β - form.

Tricalcium aluminate is contained in clinker in an amount of 4...12% and under favorable firing conditions is obtained in the form of cubic crystals up to 10-15 microns; forms solid solutions of complex composition. It is very quickly hydrated and hardens, but has a small strength and the highest intensity of heat. It is the cause of sulfate corrosion of concrete, so the content of C3A in sulfate-resistant Portland cement is limited to 5%.

Tetracalcium aluminaferrite in clinker contains in number 10...20%. The aluminoferrite phase of the intermediate clinker is a solid solution of calcium aluminoferrites of different composition, in clinkers of ordinary Portland cement its composition is close to $4CaO \times Al_2O_3 \times Fe_2O_3$. According to the rate of hydration, the mineral occupies an intermediate position between alite and Belite.

Gypsum stone

Specifications:

- Gypsum by the content of gypsum and anhydrite stone by the total content of gypsum and anhydrite, in conversion to gypsum is divided into the varieties listed in table 6.

The content of gypsum in gypsum stone is determined by crystallization water, and in gypsum anhydrite stone — by sulfuric anhydrite (SO_3)

Table 6 – Varieties of gypsum

Varieties	The content in gypsum stone, %	
	gypsum ($Ca_2SO_4 * H_2O$)	water
I	95	19.88
II	90	18.83
III	80	16.74
IV	70	14.64

- For the production of cement, gypsum and gypsum anhydrite stone should be used. In the gypsum anhydrite stone should be at least 30 % gypsum ($CaSO_4 * 2H_2O$).
- Gypsum and gypsum anhydrite stone is used depending on the size of the fraction.: 0 - 60 mm - gypsum anhydrite and gypsum stone for cement production.
- Fractions size 0 - 60 mm should not contain stone size 0 - 5 mm more than 30 %.

In some cases, in agreement with the consumer for the content of fractions of size 0 - 5 mm allowed more than 30 %, but should not exceed 40 %.

Additives[3]

Superplasticizers in most cases are synthetic polymers: derivatives of melamine resin or naphthalene sulfonic acid (C-3); other additives (SPD, OP-7, etc.) are obtained on the basis of secondary products of chemical synthesis. Superplasticizers,which are introduced into the concrete mixture in an amount of 0,15-1,2% by weightby weight of cement, dilute the concrete mixture to a greater extent than conventional plasticizers. The plasticizing effect is maintained for 1-1.5 hours after introducing the additive, and after 2-3 hours it is already small. In an alkaline environment, these additives are converted into other substances that are harmless to concrete and do not reduce its strength.

Superplasticizers allow to use of injection molding method for the manufacture of concrete products and concreting structures using concrete pumps and pipe transport of concrete mixture. On the other hand, these additives make it possible to significantly reduce the W/C, while maintaining the mobility of the mixture, and to produce high-strength concretes[7].

Mineral filler[27]

South-Kazakhstan region

Waste resources. Reserves in dumps:

- Shymkent CHP-1– 400 thousand tons;
- Shymkent CHP-2 – 200 thousand tons;
- Kentau CHP – not counted.

Physical-mechanical and chemical-mineralogical characteristics of waste.The chemical composition of the waste is shown in table 7.

Table 7 – The chemical composition of the waste

The content of oxides in the clinker, % by the weight							
SiO_2	Al_2O_3	Fe_2O_3	SO_3	MgO	CaO	Na_2O	the p.o.i
43,3	20,9	8,35	2,3	4,21	12,88	1,09	6,99

Current state of waste management. Ash is not used in the production of building materials.

According to the research of Almaty "Niistromproekt", the ash of Shymkent CHP can be used for the production of binders.

Analysis of raw materials showed that the largest man-made raw materials in the area are ash of CHP obtained by burning pulverized coal from their mineral part, which contains clay substances, quartz and carbonate rocks, proposed for use in the production of LWDB as silica.

The study of CHP waste showed that their individual particles consist of polymineral and monomineral aggregates. It was found that quartz of the waste of CHP generally has a lower degree of crystallinity than the sand Kyzylorda deposit.

The following tests were carried out to study the energy intensity of grinding. Laboratory ball mill made grinding of initial components, resulting in received LWDB various brands from LWDB-30 to LWDB-70. As a silica-containing component, waste from Shymkent CHP-1 and for comparison the sand of the Kyzylorda deposit were used. It was noticed that one species of the binder requires a different grind time, and to receive LWDB on the basis of Kyzylorda sand deposits takes half less time.

1.4 The mode of operation of the plant

Mode of operation of the enterprise and individual shops[2].

Mode of operation is determined by the number of working days per year, shifts per day, hours per shift.

When assigning the mode of operation of the shops should be guided by the rules of technological design for the relevant industries of building materials and products.

In accordance with the norms of technological design of cement plants operating mode of firing shops, cement mills and maintenance of their repartitions are used in three shifts per day with a continuous working week.

The nominal annual aund of working time of the equipment on limits is defined by the formula:

$$T_y = N \cdot n \cdot t = 250 \cdot 1 \cdot 8 = 2000 \text{ hours},$$

where N - number of working days per year;

n - number of shifts per day;

t - the length of the work shift in hours.

The estimated Fund of operating time of the technological equipment in hours on continuous and discontinuous week on the basis of which production capacity as a whole of separate lines is calculated, is defined by the formula:

$$F_{est} = T \cdot H \cdot K_{use} = 365 \cdot 8 \cdot 0{,}9 = 2628 \text{ hours},$$

where T is a number of working days per year;

K_{use} is an average index of the use equipment (0,8-0,95);

H - number of working hours per day.

Estimated working time of continuously operating equipment per year:

$$T_w = T_y \cdot K_{t.u} = 2000 \cdot 0{,}9 = 1800 \text{ days}$$

For the systematic repair of equipment selected coefficient of technical use of equipment $K_{t.u}$= 0,8 - 0,95.

The number of working days per year for intermittent lines can be determined by the formula:

$$T_w = 365 - (W + H) = 365 - (100+15) = 250 \text{ days}$$

whereW is the number of weekends in a five-day working week;

H -number of holidays.

The adopted mode of operation of the plant as a whole and for individual shops is summarized in table 8.

Table 8 – Mode of operation of the plant and individual shops

The name of the shops and departments	Number		Annual time fund in hours
	days per year	Shifts per day	
Shop of loading and unloading of raw materials	250	1	2000
Shopof crushing and grinding of raw materials	305	3	7320
Portland-cement clinker firing shop	355	3	8520
Shop of joint grinding of clinker with additives	355	2	5680
Shop of mechanochemical activation of portland-cement	355	1	2840
Packing shop	250	2	4000
Finished product warehouse	250	1	2000

1.5 Description of the technological scheme of production

LWDB is a product of grinding and mechanochemical treatment of a mixture of Portland cement, silica filler and surface-active additive. The main difference between LWDB and TmMC is the presence of a surface-active additive in the composition of raw materials. This additive not only intensifies grinding,but also significantly reduces the cost of it. Its main purpose is to reduce the water demand of the binder. So, even more significant, in comparison with the TmMC, cement savings. It can reach 50-60% [8].

A method for manufacturing binders of low water demand is known, including a joint grinding of Portland cement clinker, calcium sulfate, a water-reducing additive.

In this method, the organic dewatering substances used superplasticizer polycondensate of melamine sulfonic acid with formaldehyde. In the examples its proportion in relation to clinker is 1-3 wt. This technical solution can significantly reduce the water demand and in many cases increase the strength, including the standard strength of the product compared with cement without plasticizer. The decrease in water demand of the product according to the prototype is achieved due to the disaggregation of the product particles in the cement paste.

Mechanochemical activation and grinding is carried out in a high-intensity vibration mill, which is part of the line. In the process of treatment the mixture of binder, sand and additives in the vibration mill, along with intensive fine grinding of the mixture components, their activation occurs, allowing to fully unlock the potential of the binder. At the same time, cement savings can be 30-70% [9].

The amount of silica component that does not have hydraulic activity (ordinary quartz sand) in the initial mixture of raw materials can reach 50% of the cement mass without losing the strength of the binder. Provided the use of silica additives with hydraulic activity (fly ash), the amount of cement in the mixture can be reduced to 30%.

The shelf life of LWDB exceeds the shelf life of cement several times, which allows to increase the periods of the material warehousing.

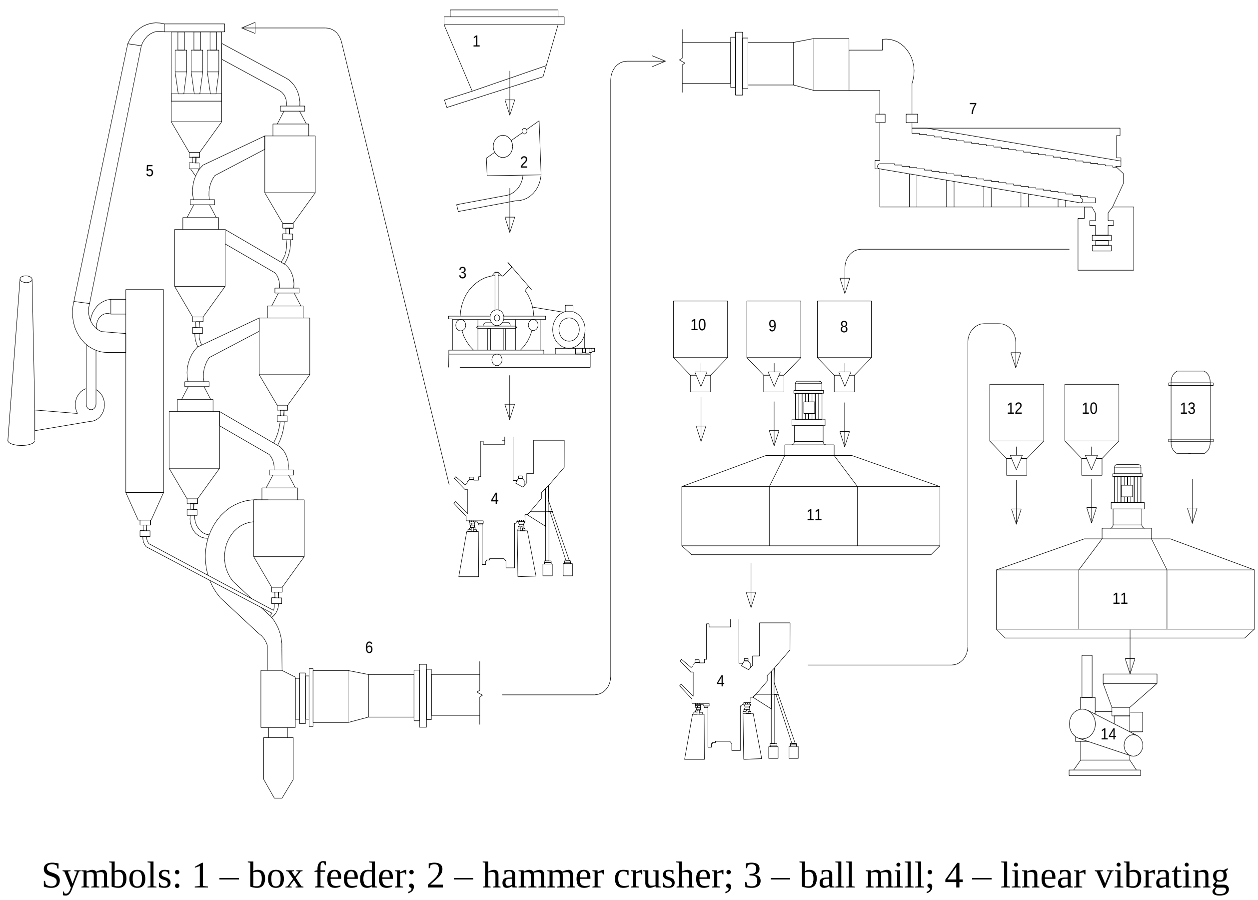
For the production of LWDB suitable stale cements that have lost their activity during storage.

Ash (or other silica component – SC) [27].

Ash from the open warehouse manually or with the aid of automechanism fed into the hopper of a screw feeder. The screw feeder evenly feeds the silica component into the rotating drum heated by a gas or liquid burner. Continuously rotating, the drum of the drying unit mixes the ash with the flue gases that dry it. The flue gases then into the extraction system, where before you get into the atmosphere, cleaned from small particles by the system of cyclones. The dried ash enters to the receiving hopper of the screw feeder (or the receiving tank of the skip lift), located under the drum dryer. The screw feeder feeds the ash to the intermediate ash storage bin where it is cooled;

Portland-cement [12].

From the hopper Portland cement screw feeder with variable frequency drive is fed into the feed hole of the vibration mill-mechanical activator.



Symbols: 1 – box feeder; 2 – hammer crusher; 3 – ball mill; 4 – linear vibrating screen; 5 – cyclone heat exchanger; 6 – rotary kiln; 7 – grate refrigerator; 8 – clinker hopper; 9 – gypsum hopper; 10 – ash hopper; 11 – forced mixer; 12 – cement hopper; 13 – superplasticizer capacity; 14 – ultrafine grinding mill.

Figure 3 – The technological scheme of production of LWDB

Modifying multifunctional additive [10].

The addition of the grinding intensifier (water-reducing additive) can be fed into the vibrating mill-mechanical activator also by a screw feeder with a frequency-controlled drive. The line can operate without the use of water-reducing additives, but in this case the quality of the product is usually lower.

Grinding and mechanical activation.

The mixture of cement, SC, modifying polyfunctional additives is exposed to the grinding bodies of the vibration mill-mechanical activator ,providing energy-intensive fine grinding and mechanical activation of the material. Vibration mill-activator MV-400 "Microtech"TM is the core of the complex. It is the intensive impact on the crushed material created by this unit that provides not only grinding, but also its mechanical activation.

1.6 Calculation of performance of technological processes

Calculation of the output program[2].

The calculation is performed on finished products and semi-finished products, based on the adopted mode of operation of the shop.

The calculation of productivity should take into account possible defects in production and production losses, the value of which is taken according to the relevant standards.

Calculation of productivity for each technological redistribution is made according to the formula (1):

$$P_c = \frac{P_o}{(1-E)/100}, \qquad (1)$$

where P_c – productivity of the calculated redistribution;

P_o – productivity of the next (technology stream) redistribution;

E - expendable industrial wastes and loss of marriage, %.

The calculations for this section are summarized in table 9.

Table 9 - Calculation of productivity by technological redistribution

The name of technological redistribution	Unit	Loss, %	Productivity per			
			year	day	shift	hour
Packing shop	t	0,5	15000	60	30	3,75
Shop of mechanochemical activation of portland-cement	t	1	15225,8	42,89	42,89	5,36
Shop of joint grinding of clinker with additives	t	1	10818,7	30,48	15,24	1,91
Firing shop	t	0,5	8807,18	24,81	8,27	1,03
Shop of loading and unloading of raw materials	t	1-2	15142,85	60,57	60,57	7,57

The performance of each technological conversion
Initial data in the calculation:
- the production method is dry
- the annual capacity of the plant is 15.000 tons LWDB-70
- composition of LWDB-70, %:
  1) PC400 D0 – 70;
  2) Ash – 29,79;
  3) S-3 – 0.21.
- the composition of PC, %:
  1) clinker – 87.;
  2) ash – 10;
  3) gypsum – 3.
- the value of fuel ash additive is 4%.
- composition of raw mixture, % (based on raw mixture calculation):
  1)Limestone – 85,52;
  2)Clay – 11,82;
  3)Candle 2.66.
- natural moisture of raw materials, fuel and additives, %:
  1)Limestone – 0.9;
  2)Clay – 18,1;
  3)Candle-0;
  4)Ash – 12;
  5)Gypsum – 5.

A low water demand binder

$$P_G=15000*1*(1+0,5/100)=15075$$

$$P_{sut}=15075/250=60.3$$

Shop of mechanical activation of portland-cement

$$P_y=15075*1*(1+(0,5+0,5)/100)=15225,75$$

$$P_{day}=15225.75/355=42.89$$

$$P_h=15225.75/2840=5.36$$

The calculation for the additive

$$P_y=15225,75*0,0021*(100/99)=30,685$$

$$P_{day}=32,297/355=0,086$$

$$P_h=32,297/2840=0,011$$

Taking into account the moisture content of the additive

$$P_y=15225,75*0,0021*(100/(100-(1+6)))=34,38$$

$$P_{day}=34,38/355=0,097$$

$$P_h=34,38/2840=0,0121$$

Calculation for mineral filler

$$P_y=15225,75*0,2979*(100/95)=4536,454$$

$$P_{day}=4774,475/355=12,779$$

$$P_h=4774,475/2840=1,597$$

Calculation for portland-cement

$$P_y=15225,75*0,7*(100/(100-0,5))=10711,583$$

$$P_{day}=10711,583/355=30,173$$

$$P_h=10711,583/2840=3,772$$

Clinker grinding shop

$$P_y = 10711,583*1*(1+(0.5+0.5)/100)=10818,699$$

$$P_{day} = 10818,699/355=30,475$$

$$P_h = 10818,699/5680=1,905$$

Calculation for clinker

$$P_y = 10818,699*0,81*(100/(100-0,5))=8807,182$$

$$P_{day} = 8807,182/355=24,809$$

$$P_h = 8807,182/5680=1,551$$

Calculation for gypsum

$$P_y = 10818,699*0,05*(100/98)=524,457$$

$$P_{day} = 551,974/355=1,477$$

$$P_h = 551,974/5680=0,092$$

Calculation for mineral additive

$$P_y = 10818,699*0,14*(100/100-1,2)=1456,589$$

$$P_{day} = 1533,014/355=4,103$$

$$P_h = 1533,014/5680=0,256$$

Take into account the humidity of additives

$$P_y = 10818,699*0,14*(100/(100-(1+21)))=1941,818$$

$$P_{day} = 1941,818/355=5,47$$

$$P_h = 1941,818/5680=0,342$$

Calculation for limestone

$$P_y = 8807,182*0,8552*(100/(100-0,53))=7194,546$$

$$P_{day} = 7572,034/250=28,778$$

$$P_h = 7572,034/2000=3,597$$

Calculation for clay

$$P_y = 8807,182*0,1182*(100/100-16)=1177,514$$

$$P_{day} = 1239,296/250=4,71$$

$$P_h = 1239,296/2000=0,589$$

The calculation for candles

$$P_y = 8807,182*0,0266*(100/100)=222,592$$

$$P_{day} = 234,271/250=0,89$$

$$P_h = 234,271/2000=0,111$$

Table 10 – Material balance of raw materials and finished products

The name of materials	Raw material consumption per, t		
	Year	Day	Hour
Limestone	7194,546	28,778	3,597
Clay	1177,514	4,71	0,589
Candle	222,592	0,89	0,111
Gypsum	524,457	1,477	0,092
Ash	1456,589+4536,454	4,103+12,779	0,256+1,597
C-3	30,685	0,086	0,011
Total			
Input	15142,846		
Output	15075		
Discrepancy	67,846	0.45 %	

1.7 Selection and calculation of the main technological equipment

In this section the calculation and selection of the main technological equipment according to the calculations of the performance of technological processes, are performed.

According to the norms, to ensure the stable operation of the shops, the equipment must be selected with a productivity higher by 10 – 15% of the productivity of the shops.

According to the calculations of the productivity of technological redistribution, the productivity of the grinding shop of raw materials is 2,325 t/h. To ensure the full operation of the plant, one hammer mill and one ball mill with a capacity of 4.5 t/h are required.

Table 11 – Sheet of the main technological equipment[2]

The name of equipment	Model	Productivity t/h	Required number of equipment	Capasity of el. eng., kW/h	Overall dimensions, mm
Hummer mill	PC4×3	8-15	1	11	400x300
Linear vibrating screen	ZK1022	4.5-90	1	6	1000x2250
Ball mill	Φ1,5×5,7	3.5-6	1	130	1500x5700
Rotary kiln with cyclone heat exchanger	Φ1.6/1.9 x36m	2.5-3.0	1	22	1600x1900x3600
Ball mill for clinker	Φ1.5x5.7	3.5	1	130	1500x5700
Ball mill for ash	Φ1.2x4.5	1.4	1	55	1500x5700
Super fine grinding mill	T130X	4—13	1	75	1300x1300x2100
Rotary packaging machine	BHYW6D	1200-1800 bags/hour	1	24	3800×2200×4000

To achieve performance of roasting 2,253 t/h we need to have one rotary kiln of size 1,6x1,9x36м with cyclone preheater.

For shop of the joint clinker grinding with additives with a capacity of 2.77 t/h, one ball mill with a capacity of 3.5 t/h is required.

In the shop of mechanochemical activation capacity is 3.89 t/h. To ensure stable operation of the shop is sufficient one vibration mill type MV-400.

Table 12 – Sheet of the transport equipment[2]

The name of equipment	Model	Required number of equipment	Productivity, m^3/h
Screw feeder	GZT-0724	4	30-79
Belt conveyor	TD75-500	3	69-217
Apron conveyor	BL650	3	20-80

1.8 Control of the quality of raw materials, production and finished products

Physical and mechanical properties of binders of low water demand can be determined by [18]; [19]; [20]; [21]. Chemical analysis of clinker, cement and LWDB produced according to [22]. The index of variation of the ultimate strength in compression of the binder of each type and brand is calculated according to [23].Any indications about setting checking according to the method of the parent organization for state testing.

The types, parameters and locations of quality control selection are listed in Appendix A (table A.1)

2 Thermotechnical part

2.1 Calculation of fuel combustion

In the directory we find the composition of a given fuel type on the fuel mass and humidity of the working mass of the fuel (WP).

Fuel is natural gas.

Table 13 – Composition of dry gas, %

CH_4^{dry}	$C_2H_6^{dry}$	$C_3H_8^{dry}$	$C_4H_{10}^{dry}$	$C_5H_{12}^{dry}$	N_2^{dry}	Σ
95,9	1,9	0,5	0,3	0,1	1,3	100

Dry gaseous fuel is converted to wet gas, which is to be burned. We accept the moisture content of 1%.

Recalculate the composition of the dry gas to wet gas:

$$CH_4^{wet}=CH_4^{dry}((100\text{-}H_2O)/100)=95{,}9((100\text{-}1)/100)=94{,}94\ \%$$

Other components remain unchanged.

Table 14 – Composition of wet working gas, %

CH_4^{wet}	$C_2H_6^{wet}$	$C_3H_8^{wet}$	$C_4H_{10}^{wet}$	$C_5H_{12}^{wet}$	N_2^{wet}	H_2O	Σ
94,9	1,9	0,5	0,3	0,1	1,3	1	100

The gas is burned with an air flow index α=1,05. The air going for combustion is heated to 600 ° C. For gaseous fuels, the heat of combustion is defined as the sum of the products of the thermal effects of the constituent combustible gases on their quantity:

$$Q_н^p = 358{,}3*CH_4^{wet}+634*C_2H_6^{wet}+907{,}5*C_3H_8^{wet}+1179{,}8*C_4H_{10}^{wet}+452{,}5*C_5H_{12}^{wet},(2)$$

$$Q_н^p =358{,}3*94{,}9+634*1{,}9+907{,}5*0{,}5+1179{,}8*0{,}3+1452{,}5*0{,}1=36160\ kJ/m^3$$

Determine the air consumption for combustion. The calculations take the following air composition: N_2 – 79,0% O_2 – 21,0%.

We find theoretically necessary air consumption for natural gas combustion:

$$L_o=0{,}0476(2*CH_4^{wet}+3{,}5*C_2H_6^{wet}+5*C_3H_8^{wet}+6{,}5*C_4H_{10}^{wet}+ 8*C_5H_{12}^{wet}),\ (3)$$

$$L_o =0{,}0476(2*94{,}9+3{,}5*1{,}9+5*0{,}5+6{,}5*0{,}3+8*0{,}1)=9{,}6\ m^3/m^3.$$

Accept moisture content of air d=10 [g/(kg dry.air)] and find the theoretically necessary amount of atmospheric air, taking into account its humidity:

$$L_o'=(1+0,0016*d)L_o=1,016*9,6=9,75\ m^3/m^3$$

The actual amount of air in the flow indexα=1,05:

$$L_\alpha=\alpha*L_o=1,05*9,6=10,08\ m^3/m^3$$

The actual consumption of atmospheric air at its moisture content d will be:

$$L_\alpha'=(1+0,0016*d)L_\alpha=1,016*10,08=10,24\ m^3/m^3$$

Determine the volume of combustion products:

$$V_{CO2}^{T}=0.01(CH_4+2*C_2H_6+3*C_3H_8+4*C_4H_{10}+5*C_5H_{12}), \quad (4)$$

$$V_{CO2}^{T}=0,01(94,9+2*1,9+3*0,5+4*0,3+5*0,1)=1,019\ m^3/m^3.$$

$$V_{H2O}^{T}=0.01(2*CH_4+3*C_2H_6+4*C_3H_8+5*C_4H_{10}+6*C_5H_{12}+H_2O+0.16*d*L_\alpha), \quad (5)$$

$$V_{H2O}^{T}=0,01(2*94,9+3*1,9+4*0,5+5*0,3+6*0,1+1+0,16*10*10,08);$$

$$V_{H2O}^{T}=2,157\ m^3/m^3.$$

$$V_{O2}^{T}=0.21(\alpha-1)L_o=0,21(1,05-1)9,6=0,1\ m^3/m^3.$$

$$V_{N2}^{T}=0.01*N_2+0.79*L_\alpha=0,01*1,3+0,79*10,08=7,976\ m^3/m^3.$$

The total number of combustion products:

$$V_\alpha^{T}=1,019+2,157+0,1+7,976=11,252\ m^3/m^3.$$

Percentage composition of combustion products:

$$CO_2=(V_{CO2}^{T}*100)/V_\alpha^{T}=(1,019*100)/11,25=9,06\ \%$$

H_2O = 19,17 %
O_2 = 0,89 %
N_2 = 70,88 %

Determine the theoretical combustion temperature. We have to find the enthalpy of combustion products given the heated air to 600^{o}C at α=1,05.

According to the i–t diagram in Appendix B (figure B.1), we find the heat of heating of the atmospheric $i_{air.}$=840 kJ/m^3

$$I_{gen.}=(Q_н^p/V_\alpha^т)+(L_\alpha'*i_{air.}/V_\alpha^т= (36160/11,252)+(10,24*840/11,252)=3978 \text{ kJ/m}^3$$

Table 15 – Material balance of combustion

Input	kg	Output	kg
Natural gas CH_4 = 94,9*0,717 C_2H_6 = 1,9*1,359 C_3H_8 = 0,5*2,02 C_4H_{10} = 0,3*2,84 C_5H_{12} = 0,1*3,218 N_2 = 1,3*1,251 H_2O = 1*0,804	 68.04 2.58 1.01 0.852 0.322 1.626 0.804	Combustion product CO_2 = 1,977*100*1,019 H_2O = 0,804*100*2,157 N_2 = 1,251*100*7,976 O_2 = 1,429*100*0,1	 201,46 173,42 997,8 14,29
Air O_2 = 10,08*0,21*1,429*100 N_2 = 10,08*0,79*1,251*100 H_2O = 0,16*10*10,08*0,804	 302,49 996,2 12,97		
Total	1386,89	Total	1386,97
		Discrepancy	0,08 0,006%

According to the i-t diagram in Appendix B (figure B.2) we find the theoretical combustion temperature at α=1,05 : $t_{teor.}$=2200^{o}C.

Determine the actual combustion temperature at η_n = 0,8.

The calculated heat content will be:

$$i_{gen.}'=i_{gen.}*\eta_n=3978*0,8=3182 \text{ kJ/m}^3$$

According to the i-t diagram in Appendix B (figure B.2) we find the actual combustion temperature at α=1,05 : $t_{act.}$=1900^{o}C.

Determine the density of the combustion products of fuel:

$$\rho_0=(1,019*1,977+2,157*0,804+0,1*1,429+7,976*1,251)/11,252=1,233 \text{ kg/m}^3$$

2.2 Material balance of raw materials

Fuel consumption is determined by the formula:

$$b = q / Q_н^p= 6500 / 36160 = 0,18 \text{kg/kg cl}$$

where q is the preliminary heat consumption for this type of furnace (6500 kJ/kg);

b – specific fuel consumption m^3/kg.

The theoretical consumption of dry raw materials per 1 kg of clinker will be:

$$M_t^d=100/(100–L.O.I.)=100/(100–35,47)=1,55 \text{ kg/kg cl}$$

The practical consumption of dry raw materials will be:

$$M_p^d=M_t^d(100/99,9)=1,55(100/99,9)=1,552 \text{ kg/kg cl}$$

The consumption of wet raw materials will be:

$$M_p^w=M_p^d(100/(100–W))=1,552(10\ /(100–36))=2,425 \text{ kg/kg cl.}$$

The total amount of material carried away from the furnace will be:

$$M_{ca}=n*M_p^d=0,03*1,552=0,047 \text{ kg/kg cl}$$

where n is the share of carried away raw materials 2-4%.

The amount of return entrainment will be:

$$M_{ca.}^r=((n–0,1)M_p^d)/100=((3–0,1)1,552)/100=0,045 \text{ kg/kg cl.}$$

According to the chemical composition of the charge, we find the content of carbonates and carbon dioxide in it, % :

$$CaCO_3=(CaO*100)/56MgCO_3=(MgO*84.3)/40.3$$

$$CO_2=(CaO*44)/56+(MgO*44)/40.3$$

where the digital values correspond to the molecular masses of chemical compounds.

$$CaCO_3=(42,35*100)/56=75,63\ \%$$

$$MgCO_3=(1,46*84,3)/40,3=3,05\ \%$$

$$CO_2=(42,35*44)/56+(1,46*44)/40,3=34,87\ \%$$

The number of hydrate water in raw mix:

$$H_2O=L.O.I.-CO_2=35,47–34,87=0,6\ \%$$

Table 16 – Material balance of raw materials

Input	kg	Output	kg
Raw mixture M_p^w	2,425	clinker	1
Return $M_{ca.}^r$	0,045	General carry away M_{ca}	0,047
		Gases evolved from raw materials: - carbonic $M_{CO2}=(M_t^d*CO_2)/100$ $M_{CO2}=(1,55*34,87)/100$ - hydrateH_2O $M_{H2O}=(M_t^d*H_2O)/100$ $MH_2O=(1,55*0,6)/100$ - physicalH_2O $M^w= M_p^w – M_p^d$ $M^w = 2,425 – 1,552$	 0,54 0,01 0,873
Total	2,47	Total	2,47

2.3 Theoretical heat input for clinker formation

The cost of clinker formation consists of the heat of endothermic decomposition reactions of raw materials during heating and exothermic reactions of clinker minerals formation during firing. As applied to the raw mixture of natural clay and carbonate materials, the theoretical effect of clinker formation is calculated at the following costs:

1.Heat consumption for dehydration of clay materials:

$$q_1=M_{H2O}*6886=0,01*6886=68,86 \text{ kJ/kg cl}$$

where 6886 thermal effect of the reaction , kJ/kg cl.

2. Heat consumption for decarbonization:

$$q_2=M_{CaCO3}*1680+M_{MgCO3}*816, \quad (6)$$

$$M_{CaCO3}=(M_t^d*CaCO_3)/100=(1,55*75,63)/100=1,172 \text{ kg/kg cl.}$$

$$M_{MgCO3}=(M_t^d*MgCO_3)/100=(1,55*3,05)/100=0,047 \text{ kg/kg cl.}$$

$$q_2=1,172*1680+0,047*816=2007,31 \text{ kJ/kg cl.}$$

3. Heat consumption for the formation of the liquid phase (since the chemical composition of the raw mixture contains Fe_2O, the liquid phase is ferrous and the heat consumption for its formation is 200 kJ/kg cl).

q_3 = 200 kJ/kg cl.

4. Heat from the formation of clinker minerals:

$$q_4=(C_3S*528+C_2S*716+C_3A*61+C_4AF*109)/100, \quad (7)$$

$$q_4=(55*528+22*716+8*61+12*109)/100=465{,}88 \text{ kJ/kg cl.}$$

The theoretical heat of the reaction of clinker formation is equal to:

$$q_т=q_1+q_2+q_3–q_4=68{,}86+2007{,}31+200–465{,}88=1810{,}29 \text{ kJ/kg cl.}$$

2.4 Heat balance of the furnace and determination of specific fuel consumption for clinker firing

The arrival of the heat:
1. The chemical heat of combustion:

$$q_x=Q_н^p*b=36160*b \text{ kJ/kg}$$

2. The physical heat of the fuel:

$$q_{ph}=b*i_f=12*b \text{ kJ/kg}$$

where i_f is the fuel enthalpy in the range from 0 °C to t_t (taken t_t=10°C)
3. Physical heat of raw material:

$$q_{ph}^r=M_p^d*i_r+M^w*i_w=1{,}552*8{,}8+0{,}873*41{,}9=50{,}24 \text{ kJ/kg}$$

where i_r is the enthalpy of raw mixture, kJ/kg
i_w – water enthalpy , kJ/kg
M^W – moisture of raw mixture, kg/kg cl.
4. The physical heat of air:

$$q_{ph}^{air}=b(L_p* i_p+L_s*i_s=b(0*0+10{,}08*671{,}2)=6765{,}7*b \text{ kJ/kg}$$

where L_p and L_s are the amount of primary and secondary air , m^3/kg
i_p and i_s – enthalpy of primary and secondary air kJ/m^3
Total the arrival of the heat:

$$b(Q_н^p+i_t+L_p*i_p+L_s*i_s)+(M_p^d*i_r+M^w * i_w), \qquad (8)$$

$$36160*b+12*b+50{,}24+6765{,}7*b=42925{,}7*b+50{,}24$$

Heat consumption:
1. Theoretical heat of clinker transformation reaction:
$q_{тт}$=1810,29 kJ/kg cl.
2. The heat of evaporation of physical water:

$$q_{eva}=M^{w}*q_{eva}=0,873*2491=2174,64 \text{ kJ/kg cl},$$

where q_{eva} – heat to evaporation of 1 kg of physical water equal to 2491 kJ/kg cl.

3. Heat lose with the clinker leaving the furnace:

$$q_c=1*i_c=1*1114, =1114,3 \text{ kJ/kg cl},$$

where i_c – clinker enthalpy at the temperature of its exit from the furnace, kJ/kg cl.

4. The heat in the exhaust gases:

$$q_{ex}^{g}=V_{CO2}*i_{CO2}+V_{H2O}*i_{H2O}+V_{N2}*i_{N2}+V_{O2}*i_{O2}, \quad (9)$$

$$V_{CO2}=V_{CO2}^{т}*b+M_{CO2}/\rho_{CO2}=1,019*\ +0,54/1,977=1,019*b+0,27 \text{ m}^3\text{/kg cl.}$$

$$V_{H2O}=V_{H2O}^{t}*b+(M_{H2O}+M^{w})/\rho_{H2O}=2,157*b+(0,01+0,873)/0,804=2,156*b+1,1 \text{ m}^3\text{/kg cl.}$$

$$V_{N2}=V_{N2}^{т}*b=7,976*b \text{ m}^3\text{/kg cl.}$$

$$V_{O2}=V_{O2}^{т}*b=0,1*b \text{ m}^3\text{/kg cl.}$$

$$q_{ex}^{g}=(1,019*b+0,27)*357,6+(2,157*b+1,1)*304,4+7,976*b*260+0,1*b*267,1$$

$$q_{ex}^{g}=3094,76*b+458,1 \text{ kJ/kg cl.}$$

5. Heat lose irretrievable entrainment:

$$q_{ent}=M_{ent}*i_{ent}=0,047*185,9=8,74 \text{ kJ/kg cl},$$

where i_{ent} is the enthalpy of the raw material mixture out of the furnace, kJ/kg cl.

6. Losses to the environment through the furnace lining:

$$q_f=к'*Q_{н}^{p}*b=0,13*36160*b=4700,8*b \text{ kJ/kg cl},$$

where к‘ – accepted for long furnaces without a refrigerator 0.13.

7. Heat loss from chemical and mechanical under burning of fuel:

$$q_{un}=к''*Q_{н}^{p}*b=0,005*36160*b=180,8*b \text{ kJ/kg cl},$$

where к‘‘ is taken to fuel gas of 0.005.

Total heat consumption:

$$1810{,}29+2174{,}64+1114{,}3+3094{,}76*b+458{,}1+8{,}74+4700{,}8*b+180{,}8*b= \\ = 5566{,}07+7976{,}36*b$$

Equating the arrival of the flow rate, determine the specific fuel consumption:

$$42925{,}7*b+50{,}24=7976{,}36*b+5566{,}07$$

$$b=5515{,}83/34949{,}34=0{,}158\ m^3/kg\ cl.$$

Specific heat consumption for clinker firing:

$$q_{ch}=Q_{н}^{p}*b=36160*0{,}158=5713{,}28\ kJ/kg\ cl.$$

Substituting the value of b = 0,158 m^3/kg cl. in the corresponding equations in the balance sheet, calculated their magnitude and bring to the table 17.

Table 17 – Heat balance of the equipment for 1 kg of clinker

Balance sheet item	kJ/kg cl	%
The arrival of the heat:		
1. The chemical heat of combustion (q_{ch})	5713,28	83,60
2. The physical heat of the fuel (q_{ph})	1,896	0,03
3. Physical heat of raw material (q_{ph}^{r})	50,24	0,74
4. Physical heat of air (q_{ph}^{air})	1069	15,64
Total	6834,416	100
Heat consumption:		
1. Theoretical heat of reaction of clinker formation (q_t)	1810,29	26,49
2. The heat of evaporation of physical water (q_{eva})	2174,64	31,82
3. Heat lose with the clinker leaving the furnace (q_c)	1114,3	16,30
4. The heat in the exhaust gases (q_{ex}^{g})	947,07	13,86
5. Heat lose irretrievable entrainment (q_{en})	8,74	0,13
6. Losses to the environment through the furnace lining (q_f)	742,7	10,87
7. Heat loss from chemical and mechanical under burning of fuel (q_{un})	28,57	0,42
Total	6826,31	99,88
Discrepancy	8,106	0,12

Technological efficiency of the furnace:

$$\eta_{tech}=(q_t/q_x)*100\%=(1810{,}29/5713{,}28)*100\%=31{,}7\ \%,$$

The thermal efficiency of the furnace:

$$\eta_{the}=((q_t+q_{eva})/q_x)*100\%=((1810{,}29+2174{,}64)/5713{,}28)*100\%=69{,}8\ \%,$$

2.5 Material balance of installation

The material balance of the plant is 1 kg clinker, data from the material balance of fuel and raw materials.

Table 18 – Material balance of installation

Balance sheet item	kg	%
The arrival of the materials: 1. The raw mixture – M_p^w 2. Fuel - b 3. Air - $b*L_\alpha*\rho_{air}$	 1,981 0,158 1.616	 52,23 3,40 44,37
Total	3,755	100
Material consumption: 1. Clinker – M_c 2. Irrevocable carry-out of raw materials –M_p^d-M_t^d 3. Raw material carbon dioxide - M_{CO2} 4. Exhaust gases from the combustion of fuel - $b*V_\alpha^t*\rho_0$	 1,006 0,002 0,543 2,204	 28,06 0,04 18,156 53,736
Total	3,755	100

3 Architectural and construction part

3.1 Preliminary data

The site of the designed plant is located in Shymkent on Tauke Khan Avenue.

The project for the construction of a plant for the production of LWDB is based on the calculated data:

- weight of snow cover for the area – 120 kg/m^2;
- outdoor air temperature the coldest days, with a probability of 0.98: -25,2 °C; 0,92: -16,9 °C;
- the temperature of the coldest five days with exceedance of 0.98: -17,76 °C; 0,92: -14,3 °C;
- normative depth of soil freezing for Shymkent – 0.8 m;
- the maximum level of groundwater is possible at the absolute level of 23.00 meters, which has no impact on the production of works on the underground part of the plant;
- seismicity of the district of Shymkent – 7 points of MSK-64;
- engineering-geological and sanitary-hygienic site is suitable for the projected construction;
- construction materials are provided by local construction companies.

Table 19 – Wind parameters in Shymkent [11]

Parameter	Month	N	NE	E	SE	S	SW	W	NW
Repeatability of wind directions, %	January	4	8	32	24	6	11	8	7
	July	9	22	25	12	3	6	8	15
Average wind speed in directions, m/sec	January	1,6	2,7	2,6	2,8	5,4	5,1	2,9	2,2
	July	3,6	5,6	2,8	2,7	3,8	4,2	3,3	3,2

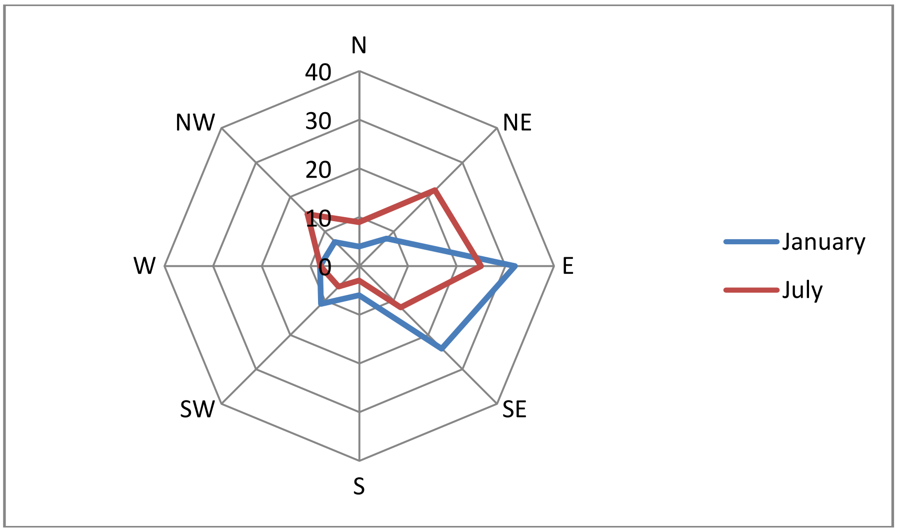


Figure 4 – Wind rose in Shymkent

3.2 Grounds for a decision of the general plan of the enterprise

The general plan in the project was designed in accordance with the requirements to [2].

The site allocated for construction is located in Enbekshi district of Shymkent, on Tauke Khan Avenue on the site for industrial development.

The decision of the General plan of a site follows from the complex decision of building, existence of the territory free from building, vertical planning with coordination in a uniform whole of planning decisions about the projected building and the sites surrounding existing buildings with their developed structure and improvement.

Planning marks of the territory are assigned in the project close to the existing ones. The slope of the planned areas provide relief of rainwater in code plane wells projected rainwater drainage.

The entrance to the building is carried out on the projected network of roadways. Entrance to the site of the enterprise is carried out on the existing asphalt-concrete driveways adjacent to Tauke Khan Avenue.

Instead of the trees and shrubs lost during the construction, compensatory gardening is provided. The free territory is planted with perennial grasses.

According to sanitary standards, the enterprise of the cement industry belongs to the first class of danger with a sanitary protection zone of more than 1000 m, respectively, the greening of the SPZ is provided.

The General plan resolved the issue of fire protection measures, they are designed in accordance with the requirements to [25].

The site of the projected plant is located on a flat area. On the site there are no buildings and structures.

All utilities and networks are located along the road and do not pass under the construction site.

3.3 Space-planning and constructive solutions

The space-planning solution of an industrial building is determined by the requirements of the production process placed in it.

In the project of the plant, in accordance with the space-planning solutions, the following buildings and structures are compactly mixed:

The space-planning solution of an industrial building is determined by the requirements of the production process placed in it.

In the project of the plant, in accordance with the space-planning solutions, the following buildings and structures are compactly mixed:

- railway overpass;
- production buildings;
- Administrative and household complex AHC;
- steamshop;

- compressor;
- garage;
- checkpoint.

Production buildings consist of the following buildings and structures:

- ridge-overpass warehouse;
- crushing and grinding department;
- firing department, which includes: a cyclone heat exchanger, decarbonator, rotary kiln, grate refrigerator;
- clinker grinding department;
- department of mechanochemical activation;
- packaging department;
- finished product warehouse FPW.

The production building is made of precast reinforced concrete structures. The frame consists of reinforced concrete stepped columns with consoles, for supporting crane beams, with a cross section of 400x400 mm and a step of 6.0 m. The columns are placed on a reinforced concrete foundation of the glass type. Used roofing roll type, mounted on a ribbed plate cover. The roof structure is based on the reinforced concrete truss.

The depth of the foundation

The depth of foundation is determined by the depth of soil freezing. The depth of soil freezing is determined by the formula:

$$d_{fn} = d_0 \cdot \sqrt{M_t}\,, \qquad (10)$$

where d_0 – index depending on the type of soil in Appendix C (table C. 1);

M_t is the sum of average monthly negative temperatures.

$$d_{fn} = 0{,}23 \cdot \sqrt{3} = 0{,}398м$$

Accordingly, the initial estimated depth of soil freezing was 0.398 m. The required value of d_{fn} is multiplied by the correction factor, based on our conditions which is 0.7 in Appendix C (table C. 2):

$$d_{fn}' = 0{,}398 \cdot 0{,}7 = 0{,}279м$$

The actual depth of foundation is 0.279 m ≈ 0.3 m

Railway overpass

The building is used for loading and unloading of raw materials and finished products. It has a through passage on the railway tracks, 5 docks for vehicles. The building is one-storey, made of metal. Designed in the following dimensions: length – 60.00 m, width – 12.00 m, height from 0.00 – 8.00 m.

Raw material warehouses

Facilities of this type are mainly used for storage of raw materials. Made of metal. Have a total area of 684,00 m^2. Equipped with belt conveyors and loading and unloading cranes.

Calculation of bulk material warehouses

When designing and calculating warehouses, it is necessary to determine:

1. The purpose of the warehouse (basic, consumable) and the type of stored material.
2. Standard storage time of the material in the warehouse.
3. Type of warehouse and type of mechanization.
4. Calculate the required capacity of the warehouse and choose its size (length, width, height of the stack).
5. Type of receiving devices and auxiliary mechanisms ensuring their smooth operation.

Calculation of the spinal and hopper warehouses

The size of the warehouse depends on the type and shape of the stack, largely determined by the selected mechanization scheme. The calculation is made in Appendix C.

Table 20 – Estimated capacity of warehouses

The name of warehouse	Calculated parameter		
	volume, м^3	Area, м^2	Quantity
Limestone warehouse	285,5	158,6	-
Clay warehouse	15	8,3	-
Storage of clinker	332,17	276,8	-
Ash warehouse	1003,4	446	-
Gypsum silos	63,6	-	1
Cement sils	523,7	-	7

AHC

The complex of buildings of administrative assignment and domestic premises. Made of two floors of effective brick. The roof is placed on wooden beams. It has the following dimensions: length – 20,00 m, width – 10,00 m, height from the mark 0,00 – 8,00 m.

Additional purpose buildings and structures

This category of buildings and structures located on the general plan include:

- boiler, size 24,0x12,0m;
- garage, size 24,0x9,0m with three docks;
- checkpoint, size 6,0x4,0m.

4 Economical part

4.1 Cost items for the production

The section of cost items contains all the information on the costs spent on the production of binders of low water demand.

The cost of production of plant is defined from the following types of expenses:

- raw material costs;
- electricity costs;
- the cost of conventional fuel;
- the cost of salaries of employees.

Raw material costs

Limestone

The market price per ton of limestone from Sastobe deposits is 3088,5tenge.

Clay

The clay necessary for the production of Portland-cement will be brought from the Badam deposit of loams in 25 – 30 km from the city, at a market value per ton in 1560 tenge.

Ash

In the city of Shymkent there are three CHP, with waste in the form of ash, suitable for the production of both Portland cement and LWDB. The average cost of three CHP per ton of ash is 1500 tenge.

Superplasticizer

Superplasticizer C-3 in powder form will be supplied by LLP "Damu – Chemistry" at a price of 400 tenge per kilogram.

Electricity costs

All technological equipment at the projected plant works at the expense of the electric power. The total capacity of all technological equipment is 447 kW•h. The cost of 1 kW•h of electricity in the city of Shymkent for industrial facilities since 03.2018 is 23.22 tg.

The cost of conventional fuel

In addition to electricity, the plant has installations operating at the expense of burned fuel. These include a rotating furnace with a cyclone heat exchanger, boiler plant furnace. The total consumption of conventional fuel per hour of all thermal units is 540 kg. The cost of conventional fuel per 1 m^3 is 30.78 tenge.

The cost of salaries of employees

To determine the total cost of employees' wages, it is necessary to determine the number of employees and their wages, respectively. Data on employees of plant are given in the regular sheet in Appendix D (table D.1.)

4.2 Cost of production

The cost of production consists of all the above costs per unit of production.

Table 21 – Cost of one ton of LWDB

Type of costs	Cost of one ton of LWDB, tenge
Raw material costs	
Limestone	1497,6
Clay	128,1
Ash	593,85
Superplasticizer	840
Total in raw materials	**3059,55**
Electricity costs	
Hummer mill	38,3
Ball mill	1132
Rotary kiln	383,13
Mill for clinker	1938,8
Mill for ash	325,08
Super fine grinding mill T130X	134,7
Rotary packaging machine	46,44
Equivalent fuel	3695,8
Total in electricity costs	**7694,25**
The costs of salaries of employees	
Salary of management personnel	1700
Salary of shop staff	2500
Salary of support staff	400
Total in salary	**4600**
Total in costs	**15353,8**
Unforeseen expenses 6%	921,228
Total costs	**16275,028**

4.3 Calculation of investment costs

Investment costs - costs carried out at the investment stage of the project.

Investment costs form the need for financial resources necessary for the implementation of the investment project, i.e. the resources necessary for the acquisition and creation of fixed assets, financing of non-capitalized costs, acquisition of current assets.

This section of investment costs consists of all types of expenses that need to be made for the construction of buildings and structures, equipment and commissioning.

The amount of investment costs largely determines the effectiveness of the project. Their objective assessment is a prerequisite for the successful implementation of the project. Implementation of even the most profitable projects becomes impossible if there is not enough funding.

Table 22 – Estimated cost of major construction projects

The name	Area, м^2	Estimated cost, thousand tenge
Production building		
Railway over pass	720	11 337,9
Storage of limestone, clay and ash	648	25 833,97
Additive warehouse	36	1 379,8
Preparatory department	288	13 454,8
Clinker grinding department	216	10 850,86
Department of mechanochemic alactivation	127,5	4 126,7
Department of packaging and FGW	288	5 898,54
Auxiliary building		
Administrative and household complex	200	2 825,9
Steamshop	288	11 424,98
Fuel depot	216	9 995,7
Garage	216	5 632,6
Checkpoint	24	353,7
Total construction costs		106 115

Table 23 – Calculation of the cost of equipment

Thw name of equipment	Model	Quantity	Price per unit, thousand tenge	The sum, thousand tenge
Hummer mill	PC0,4×0,3	1	988,141	988,141
Linear vibrating screen	ZK1022	1	558,95	558,95
Ball mill	Ф1,5×5,7	1	5 589,48	5 589,48
Rotary kiln with cyclone heat exchanger	Ф1.6/1.9x36m	1	16 235,063	16 235,063
Ball mill for clinker	Ф1.5x5.7	1	5 589,48	5 589,48
Ball mill for ash	Ф1.2x4.5	1	5 589,48	5 589,48
Super fine grindin gmill	T130X	1	6 035,857	6 035,857
Rotary packaging machine	BHYW6D	1	603,66	603,66
Bunker	-	5	127,76	638,8
Screw feeder	GZT-0724	4	427,995	1 711,98
Belt conveyor	TD75-500	3	452,748	1 358,245
Apron conveyor	BL650	3	694,7	2 084,08
Total in the cost of the equipment				46 983,228
Installation and commissioning, %		15		7 047,484
Total in equipment				54 030,712

Table 24 – Composition of investment costs

Cost items	The sum, million tenge
Estimated cost of major construction projects	106,115
Estimated calculation of earthworks and landscaping	14,83
The calculation of the cost of the equipment	54,03
Total	174,975

Table 25 – Estimated calculation of excavation and improvement

The name	Unit	Quantity	Price per unit, thousand tenge	The sum, thousand tenge
Site preparation	ha	0,97	798,5	774,537
Laying of cablelines	rm	227,5	2,8	635,8
Laying of water supply and Sewerage pipes	rm	628,8	2,545	1 600,18
The arrangement of round precast concrete manholes	pieces	16	226,073	3617,17
Organization of road construction works	m^2	988,2	4,775	4 718,3
Landscaping	m^2	2424,3	1,44	3 483,8
Total earth works				18 572,25

Investment costs are calculated according to the above calculations and are summarized in the table 24.

Calculation of profit from the sale of finished products of the plant

Table 26 – Calculation of profit from sales of LWDB-70

Name of indicator	Unit	Quantity
Annual capacity of the plant	t	15 000
Price including VAT, 12%	tg/t	25 000
Total revenue	Thousand tenge	375 000
Including VAT	Thousand tenge	45 600

Table 27 – Net profit of the plant

Name of indicator	The sum, thousand tenge
The amount of profit before deduction of expenses on interest, taxes, depreciation and accumulated depreciation	375 000
without VAT	330 000
Excluding costs	85 874
Excludingin come tax	68 699
Taking into account depreciation charges	76 754

The payback of the projected plant for the production of LWDB-70 is calculated as follows:

$$P_I = \text{Investment cost / Net profit} = 174\ 974\ 000/76\ 754\ 000 = 2{,}28.$$

Payback of the project is 2 years and 3 months.

4.4 Technical and economic features of the enterprise

Profitability can be defined as an indicator of economic efficiency, reflecting the degree of efficiency of the use of material, monetary, industrial, labor and other resources.

Profitability indicators are divided into different groups and calculated as the ratio of the selected meters.

The main types of profitability are the following indicators:

- profitability of actives.
- profitability of fixed assets.
- profitability of sales.

Profitability of actives

Profitability of actives is a financial ratio that shows the profitability and efficiency of the enterprise. Return on assets shows how much profit the organization received from each ruble spent. Return on assets is calculated as the quotient of the net profit divided by the average amount of assets multiplied by 100%.

Profitability of actives=(Netprofit/the average annual value of assets) * 100%, (11)

Profitability of actives= (76 754/255 125)*100%=30,08%

Profitability of fixed assets

The profitability of fixed assets or the profitability of fixed assets is the private division of net profit to the value of fixed assets multiplied by 100%.

Profitability of FA=(NP /the average annual cost of fixed assets) * 100%, (12)

Profitability of FA = (76 754/160145)*100%=47,93%

The indicator shows the real return on the use of fixed assets in the production process.

Profitability of sales

Profitability of sales is determined by the following formula:

Profitability of sales=(NP/cost of sales))*100%=(76 754/244125)·100% =31,44%

Table 28 – Technical and economic indicators of the enterprise

Indicators	Units	Value
Annual output		
a) in kind	t	15000
b) in terms of value	million tenge	375
The total cost of all marketable products	million tenge	240, 125
Including 1 t	thousand tenge	16, 275

Conituation of the table 28

Indicators	Units	Value
Annual profit	million tenge	68, 699
Production assets	million tenge	174, 975
Including basic production assets	million tenge	129, 912
Normalized working capital (10%)	million tenge	37,5
Profitability:		
a) actives	%	30,08
b) production assets	%	47,93
c) soldproducts	%	31,44
Production costs for 1 tenge of commercial products	unit	0,65
Payroll number of people employed	person	42
Including workers		25
Annual output per worker		
a) inmonetary terms	thousand tenge	8 928, 57
b) in kind	t	20,45
Total estimated cost	million tenge	174, 975
Specific investment	tenge / t	11 665
Project payback period	years	2,28

When calculating the technical and economic indicators of the plant for the production of binders of low water demand with a capacity of 15,000 tons per year, such key indicators as profitability of production, annual production of workers, specific investments and payback period were determined. Despite the rather low annual output of one worker, the payback period is 2 years and 3 months, which in modern capitalist market conditions is very positive.

CONCLUSION

When drawing up the diploma project with the theme " Plant for the production of low water demand binder in the city of Shymkent with a capacity of 60 tons per day", the following data were obtained and calculated:

1. According to the results of marketing analyses, identified the need for the development and creation of a new type of binder, which in its properties is much better than Portland cement.

2. Determined the composition of the binder, which consists of limestone, clay, ash and superplasticizer additives. For the production of binders of low water demand in the city of Shymkent, determined the deposits of raw materials: limestone is delivered from the Sastyubinsk Deposit in 40 kilometers from the city; clay from the Badam Clay Deposit in 25 kilometers from the city, ash is transported from local CHP.

3. Mode of operation of the plant: for the raw material shop provides one shift of 250 working days a year; for the preparation shop – 3 shifts of 305 working days; for the shops of firing, grinding clinker and mechanochemical activation provided 3, 2 and 1 shift of 355 days a year; packing shop and warehouse of finished products works 250 days a year, 2 and 1 shift respectively.

4. Given the high prices for Portland cement, it was decided to produce it yourself. A method of manufacturing dry, because it is more economical. The technology of production of binders of low water demand using waste CHP.

5. Material balance of the plant: the consumption of raw materials 15142,846 tons per year, for the output of 15075 tonnes per year, the residual error is 0.45 %. The material balance of the heat plant per 1 kg clinker is: the arrival of materials – 3,755 kg; consumption – 3,755 kg.

6. According to the technological calculations for the selection of equipment, the following equipment was selected: hammer mill, linear vibrating screen, ball mill, rotating furnace with cyclone heat exchanger, ultra-fine grinding mill, rotary packaging machine.

7. All climatic, seismic, geological and sanitary conditions of the construction site were analyzed for the design of the plant. The depth of soil freezing and the depth of Foundation is calculated. Calculation of warehouses of bulk materials was made.

8. According to the calculations of the cost, determined the cost of 16275,028 tenge per ton. Set the cost of finished products in 25 thousand tenge. Calculated all the costs of production, construction of industrial facilities. The working staff of the plant was 44 people. Calculated return on assets, fixed assets and sales. The payback period of the project was 2 years and 3 months. The projected plant for the production of binders of low water demand in the city of Shymkent, with a capacity of 60 tons per day, has a very positive technical and economic indicators, a very short payback period, and also produces a construction material that currently does not exist in the market of Kazakhstan, which will allow LWDB to take its place in the segment of the market of building materials

List of abbreviations

LWDB – low water demand binder
CS – cone slump
HHT – heat and humidity treatment
VAT – value added tax
PC – portland-cement
CHP – combined heat plant
TMC – thin-milled multicomponent cement
SC – silica component
MF – mineral filler
AHC – administrative and household complex
FPW – finished product warehouse
NP – net profit
AAVA – average annual value of assets
AACFA – average annual cost of fixed assets
FA – fixed assets
SP – sale of products

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Appendices

Appendix A

Table A.1 - Control of quality of raw materials, process of production and finished products

№	Techno logical post	Convenient parameter	Place of probation	Type of probation	The periodicity of the average probation	Methods of control
1	2	3	4	5	6	7
1	Quarry	Limestone	Grit from blast holes	Manual sampling	As mining of minerals	X-ray spectral, a gravimetric
2		Clay	Face board			
3	Storage and preparation of raw materials, mineral additives and fuel	Limestone	From a belt conveyor, after secondary crushing	Probation machine with the setting for the selection, preparation and transportation of samples	Once per shift	X-ray spectral, a gravimetric, titration
					Once a month	Photometric, flame photometer, titrimeter
4		Clay, ash (dry production method)	From a belt conveyor, after crushing and drying		Once per shift	X-ray spectral, weight
					Once a month on average samples	A gravimetric, photometric flame photometer, titrometer
5		Cinders	From a belt conveyor or from wagons	Manual sampling	From each incoming party	A gravimetric
					Once a month	Photometric, flame photometer, titrometer
6		Liquid fuel	From the tank		From each incoming party	Thermotechnical
7		Cement additives	From a belt conveyor or from wagons	Probation machine with the setting for the selection, preparation and transportation	From each batch or once a month	Weight, photometric, GOST 25094-82
8		Gypsum				Weight, chemical
9	Preparation of raw mixture	coarse grinding raw flour	Combining flows at the entrance to the raw mill		Once per hour	X-ray spectral, a gravimetric
					Continuously	X-ray spectral
10		Fine-milled raw flour	At the exit of the mill	Raw flour sampler	Once per hour	X-ray spectral, a gravimetric
					Continuously	X-ray spectral
11		Raw flour	Combining flows at the entrance to the mixing silo	Probation machine with the setting for the selection, preparation	Once per hour	X-ray spectral, a gravimetric

Continuation of the Appendix A

Continuation of table A.1

1	2	3	4	5	6	7
12	Preparation of raw mixture	Raw flour	Combining flows on the node power furnace	Too	Once every two hours	X-ray spectral
					Once a month for a single probe	A gravimetric, photometric
13			Filling units from mixing silo to spare	Too or manual sampling	Once every two hours	X-ray spectral
					Once a month for a single probe	A gravimetric
14	Clinker firing	Solid injection fuel	The pipelines before or after cyclones or heat before the injector	Bulk material sampler	1-2 times per shift on average samples	
					Once a day	Thermotechnical
					Once a month	Thermotechnical, photometric
15		Clinker	After the refrigerator of furnace units	Clinker samplers or manual sampling	Once every two hours	Chemical
					Once a day on average samples from all furnaces	Photometric, GOST 310.1 – 76 GOST310.4-81, petrographic
16	Cement grinding	Cement	After each mill	Bulk material sampler	Every 2 hours	A gravimetric (SMM-1), chemical, x-ray
17			From pipelines at the exit of silo		After filling the silo or grinding the batch	A gravimetric (SMM-1), chemical, x-ray, GOST310.4-81,
18	The shipment of		From pipelines at the exit of silo	Probation machine with the setting for the selection, preparation and transportation of samples of fluid materials.	From each batch	GOST 310.1 – 76 GOST310.4-81,
19	LWDB grinding	Ash	From a belt conveyor		Once per shift	X-ray spectral, a gravimetric
					Once a month on average samples	A gravimetric, photometric, titrometer
20		Additive C-3	From the pipeline at the exit of из tanks		From each batch or once a month	Photometric, GOST 25094
21		BLWD	From pipelines at the exit of silo		From each batch	GOST 310.1-76

Appendix B

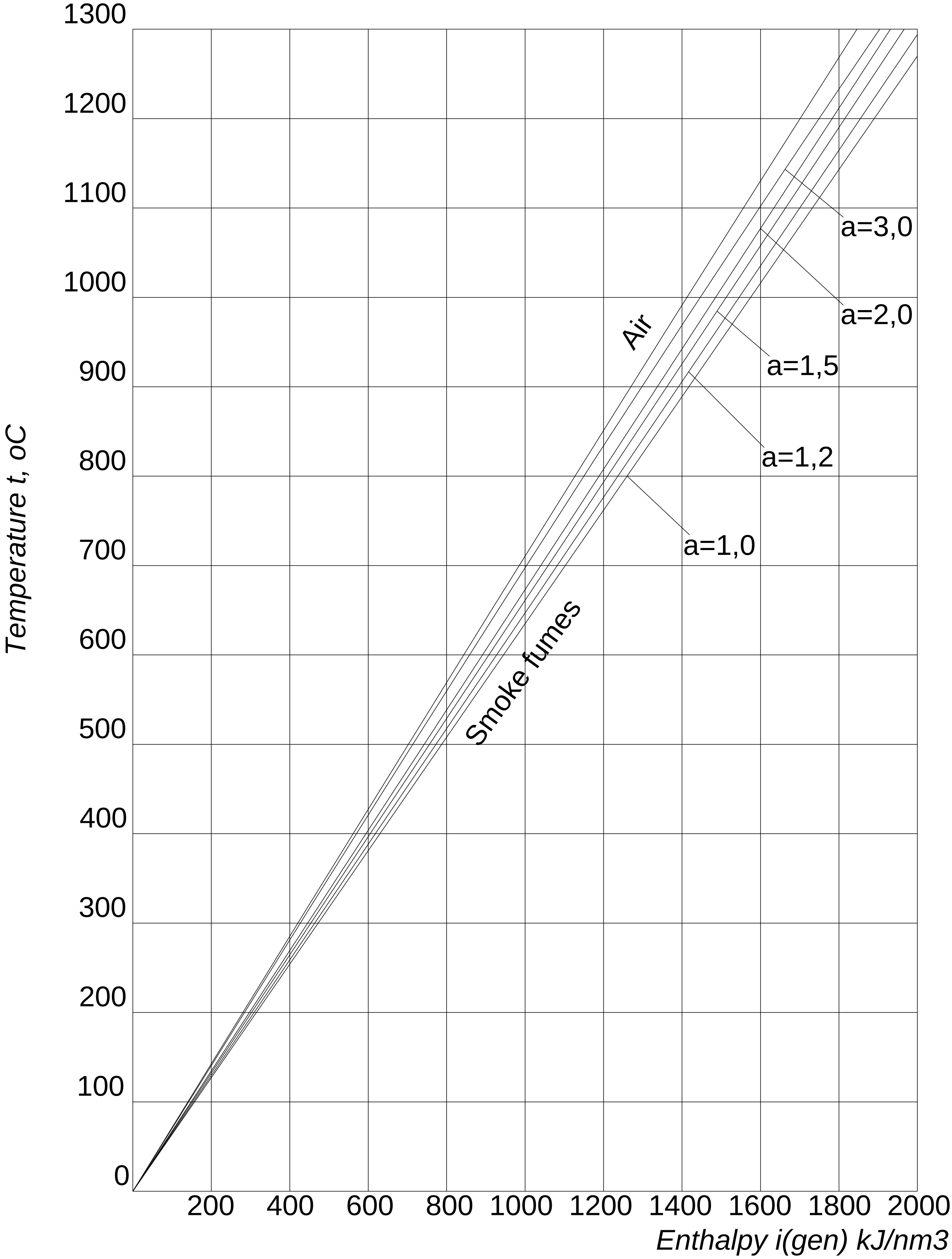

Figure B.1 – i-t diagram for temperatures between 0 and 1300 ° C

Continuation of the Appendix B

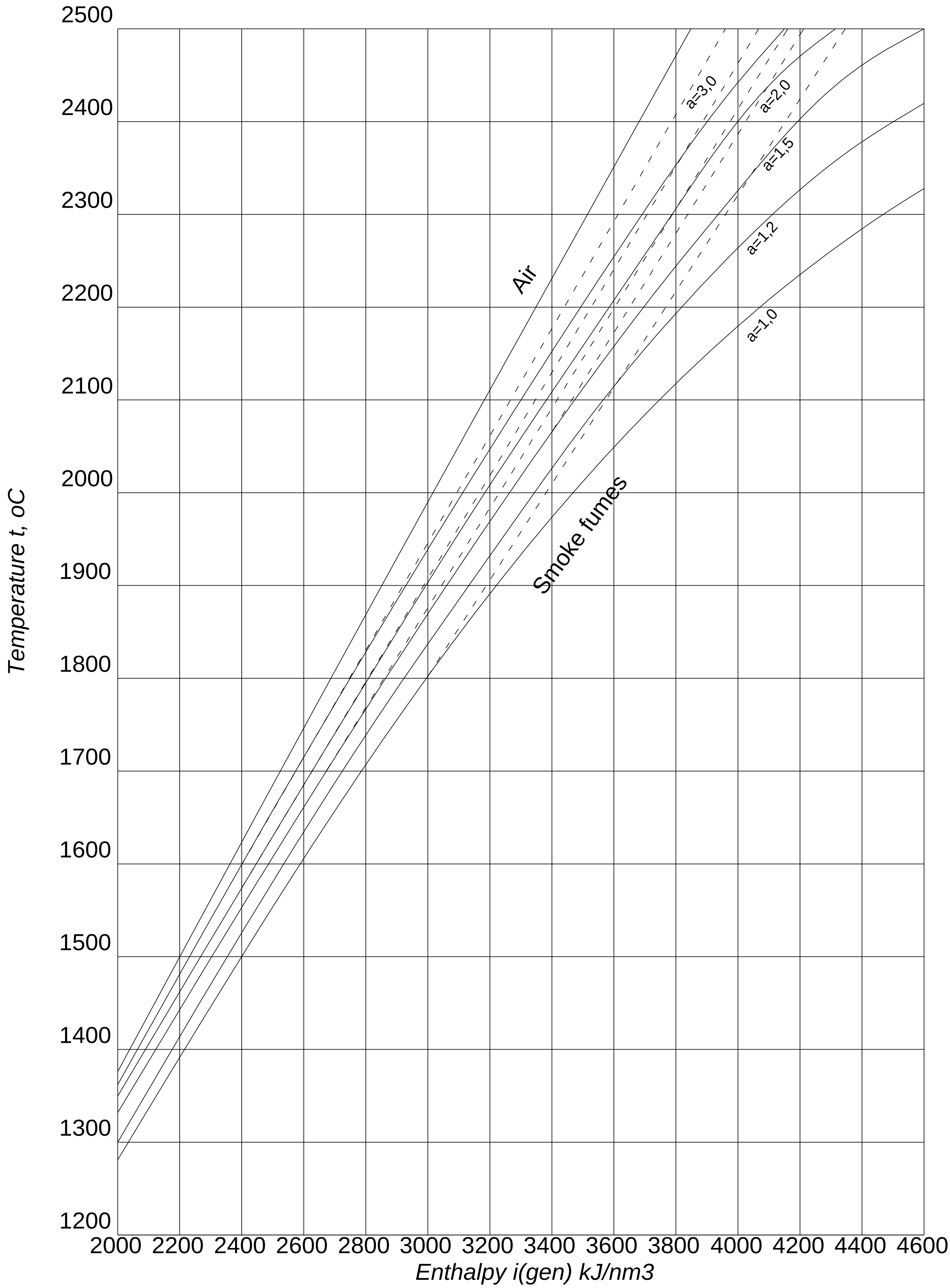

Figure B.2 – i-t diagram for high temperatures

Appendix C

Table C.1 – Index d_0 by the type of soil

Type of the soil	Index d_0
Coarse soils	0,34
Coarse sand	0,3
Fine loose sands and sandy loam	0,28
Clay and loam	0,23

Table C.2 – Correction for the features of the temperature regime in the room

Construction features	The standard coefficient used in the calculation of the average daily air temperature in the premises, ^{o}C				
	0	5	10	15	20 and more
Without basement, with floors on the ground	0,9	0,8	0,7	0,6	0,5
Without basement, with floors on the logs	1,0	0,9	0,8	0,7	0,6
Without basement, with floors in the insulated basement	1,0	1,0	0,9	0,8	0,7
With basement or technical техническим underground	0,8	0,7	0,6	0,5	0,4
Unheated	1,1				

Table C.3 – Norms of stocks and storage of raw materials, basic and auxiliary materials, semi-finished products and finished products

The name of material	Stocking, day			Note
	Annual production capacity of the plant on cement			
	Up to 1 million tons per year	1,0-2,0 million tons per year	More than 2.0 million tons per year	
Carbonate component	10	3-5	3-4	
Clay component	3	2-3	2-3	With non-adhesive material
Clinker	10	4-5	4	A fallback warehouse with a volume of 3-5% of the annual capacity of the plant
Hydraulic and corrective additives and gypsum	30	30	30	
Surfactants, AIDS, mineralizer	30	30	30	
Cement	20	10-15	10	
Fuel oil as the main fuel (at delivery by railway)	15	15	15	

Continuation of Appendix C

Table C.4 – The value of the index of use of the theoretical volume of the stack

Stack type and shape	K_2
Warehouse with grab crane and retaining walls (in the presence of separation walls)	0,85-0,90
The stacked trapezoidal cross-section	0,75-0,80
The Stacks of triangular cross-section	0,45-0,50

Table C.5 – Bulk mass and angle of repose of materials

Material	Bulk mass, t/м^3	angle of natural slope and slope, degrees.
Limestone, coarse	1,5-1,8	35-40
Clay shale	1,4-1,5	-
Rotary kiln clinker	1,50-1,65	33
Pyrite cinders	1,6	-
Sand	1,6	35
Blast furnace dry slag	0,5-0,8	35
Gypsum	1,45	30

Table C.6 – Parameters of silos

The diameter of the silo, м	The height of the cylindrical part silo's, м	Net capacity silo's Vs, м^3
3,6	9,0	80,0
6,0	21,6	500,0
12,0	19,8	1700,0
12,0	33,0	3000,0

The calculation of the approximate capacity (m^3) and area (m^2) of the warehouse is made according to the formulas:

$$V_H = \frac{A_k P_y C_H}{365 K_H \sigma_H}, \tag{C.1}$$

$$F = \frac{V_H}{K_2 H_M} K_1, \tag{C.2}$$

where V_H — the need for the material storage capacity, m^3;
A_k — performance plant for clinker, tonnes/year;
P_y — specific material consumption per 1 ton of clinker;
C_H — normative stock of material in days (table B. 1);
K_H — index of use of units for which this material is used;
σ_H - bulk of material, t/m^3 (see table B. 3);

K_1 — index, taking into account gaps and passages in the warehouse, unloading ditches, repair sites, etc.;

K_1~1,2 – 1,5;

K_2 —index of use of the theoretical volume of the stack, depending on the shape and size of the stack (table B. 2);

$H_м$ — the maximum height of the stack when using a grapple $H_м = H_{гр} — 1$; where $H_{гр}$ — the maximum height of the grapple, m.

Limestone warehouse

$$V_H = \frac{12794,5 \cdot 0,855 \cdot 10}{365 \cdot 0,7 \cdot 1,5} = 285,5 м^3$$

$$F = \frac{285,5}{0,45 \cdot 6} 1,5 = 158,6 м^2$$

Clay warehouse

$$V_H = \frac{12794,5 \cdot 0,14 \cdot 3}{365 \cdot 0,7 \cdot 1,4} = 15 м^3$$

$$F = \frac{15}{0,45 \cdot 6} 1,5 = 8,3 м^2$$

Storage of clinker

$$V_H = \frac{15716,7 \cdot 0,81 \cdot 10}{365 \cdot 0,7 \cdot 1,5} = 332,17 м^3$$

$$F = \frac{332,17}{0,45 \cdot 4} 1,5 = 276,8 м^2$$

Ash warehouse

$$V_H = \frac{(15716,7 \cdot 0,14 + 22119 \cdot 0,2979) \cdot 30}{365 \cdot 0,9 \cdot 0,8} = 1003,4 м^3$$

$$F = \frac{1003,4}{0,45 \cdot 6} 1,2 = 446 м^2$$

Determining the size of the silo storage of lump materials is performed in the following order:

1. According to the formula (C.1), the required capacity of the warehouse (V_H) is calculated.

2. The number of silos is determined from the expression:

$$n = \frac{V_H}{Vs} \quad (C.3)$$

where V_s is the useful volume of one silo, (table B. 4)
Gypsum silos

$$V_H = \frac{15716,7 \cdot 0,05 \cdot 30}{365 \cdot 0,7 \cdot 1,45} = 63,6 м^3$$

$$n = \frac{63,6}{80} = 0,795 \approx 1$$

Cement silo

$$V_H = \frac{22119 \cdot 0,7 \cdot 20}{365 \cdot 0,7 \cdot 1,5} = 523,7 м^3$$

$$n = \frac{523,7}{80} = 6,55 \approx 7$$

Appendix D

Table 4.1 – Staff list and monthly payroll of the projected BLWD plant

The name of departments and professions	Number of employees			Total	Estimated salary per 1 worker, thousand tenge
	1 shift	2 shift	3 shift		
Administrative and management personnel					
Geneneral director	1			1	250
Deputy of general director for production issues	1			1	200
Deputy of general director for economic issues	1			1	200
Deputy of general director for commercial issues	1			1	200
Chief engineer	1			1	175
Chief process engineer	1			1	175
Chief power	1			1	175
Financial department					
Economist	1			1	150
Accountant	1			1	150
Department of supply, sales and foreign economic relations					
Responsible for foreign economic relations and marketing	1			1	150
Responsible for logistics and sales	1			1	150
Personnel department					
Head of department	1			1	150
Total in AMP				12	2125
Shop staff					
Operator of loading/unloading shop	1			1	125
Loader driver	1	1		2	150
The driver of the bulldozer	1	1		2	150
The operator of the preparatory department	1			1	125
Firing department operator	1	1	1	3	125
Mechanic	1	1	1	3	125
Grinding department operator	1	1		2	125
The operator of the Warehouse of finished products	1			1	125
Laborer	2	2	2	6	100
Cement truck driver	1	1		2	150
Quality control					
Technician	2			2	125
Total in shop staff				25	3125
Support staff					
Cleaner	1	1		2	100
Guard	1	1	1	3	100
Total in support staff				5	500
Total in plant				42	5750

Continuation of the Appendix D

Table D.2 – Depreciation

Name	Costs, thousand tenge	Depreciation, %	Depreciation, thousand tenge
Estimated cost of major construction projects	106 115	2,5	2 652
The calculation of the cost of the equipment	54 030	10	5 403
Total	160 145		8 055