Russian Academy of Engineering (RAE)
Moscow State University of Railway Engineering (MIIT)
Kama Institute of Humanitarian and Engineering Technologies (KIHET)

B.GUSEV

DEVELOPMENT OF PREFABRICATED REINFORCED CONCRETE INDUSTRY IN THE SOVIET UNION (1981-1990)

(technological platform)

2nd Enlarged Edition

Izhevsk 2015

УДК 666.97
ББК 38.53я73

Gusev B.

Development of prefabricated reinforced concrete industry in the Soviet Union (1981-1990) Izhevsk, Publishing House «KIT», 2015. 113 p.

ISBN 978-5-902352-57-0

PREFACE

At present Russia is a country with an enormous territory and a great demand for dwellings and constructions of different purposes. That's why, all modern construction technologies and materials are in great demand at our home construction market. The production of prefabricated reinforced concrete structures is in special demand.

For the last 15 years in domestic construction there has been paid much attention to the cast-in-place construction technology. Having increased the output, the majority of the construction organizations which were engaged in cast-in-place construction couldn't develop a reliable control system. For this reason, the quality of cast-in-place structures and constructions remains to be poor. Besides, weather conditions don't make it possible to secure some advantages for mass reinforced concrete in Eurasia northern regions.

This paper presents to the reader great achievements and technical practices in the industry of prefabricated reinforced concrete in the second half of the XX century. What is more, the fathers of these achievements were Soviet engineers. Therefore, it is gratifying to emphasize that in terms of the output of prefabricated reinforced concrete the Soviet Union took the 1st place in the world and by 1990 it produced 135-140 million m^3.

One of the reasons (rather internal than external) was the lack of due attention to prefabricated reinforced concrete, in particular to panel houses. In the 90s residential area development was unimpressive and characterless. However, since 2000 Moscow construction practices showed magnificent results in aesthetic expressiveness of constructional buildings.

The monograph investigates many aspects, including historical parallels which are of current interest i.e. how labor productivity was raised, how was carried out a battle (That's right! Battle!) to improve working conditions, reduce manual operations as well as energy efficiency and material concumption when applying new technologies.

Today, when economics is considered to be unstable, it is necessary to pay first of all attention to currently operating plants which produce prefabricated structures. This includes the creation of new work positions, increase in production sector up to the level of some countries in the world, quality improvement of residential and other buildings. Adopting of all these measures is impossible without global cooperation. On the part of business community it is required to develop new quality standards for ensuring high precision and esthetic expressiveness.

This monograph can be used by engineers, research workers and students of building trades and will be interesting to a wide range of adjacent professions and readers including historians and economists.

Chairman of the Construction Technology and Housing and Utilities Infrastructure Department, Kama Institute of Humanitarian and Engineering Technologies (KIHET)
Doctor of Engineering Science
S. Spiridonov

INTRODUCTION

Construction engineering is considered to be one of the key leading economic sectors of the country. Apart from the development of capital equipment for other sectors, construction engineering solves a huge social issue, providing housing for citizens as well as erecting cultural, household, educational and other complexes.

Currently and in the long run concrete and reinforced concrete will remain the main constructional materials, having high strength properties, durability, usability and potential for comprehensive utilization after the end of their working life. In an overall construction cost, reinforced concrete makes up 23 – 30%, despite its low prime cost.

In 1981-1990, the production of prefabricated reinforced concrete was at its height and made up 135-140 million m^3 and **the Sovied Union was the leading country** in the use of prefabricated reinforced concrete structures. In those years, the purpose of the development in prefabricated reinforced concrete industry was to reduce costs, including up to 10% of cement, heat consumption as well as to raise labor productivity and create new mechanized and automated technological lines.

Since the 70's, the author has extensively worked on the development of new effective types of vibration equipment for a large assortment of reinforced structures. In his works chemical and mechanical activation of concrete mixes with the use of low-frequency vibroequipment and various plasticizers, such as sulphite and zymic distiller's wort at first, later modified lignosulfonate, then chemical agents i.e. superplasticizers and effective plasticizers such as S-3, 10-03, LSTM-2 and some others gained widespread currency.

In 1986, there was set a challenge to significantly raise labor productivity up to 2,5 times and the author took the lead to create fundamentally new technological lines.

This paper presents effective structures made of prefabricated reinforced concrete. There was carried out an analysis of new technological lines and equipment created at Concrete and Reinforced Concrete Research

Institute of the USSR State Committee for Construction, All-Union Concrete and Reinforced Concrete Research Institute of the USSR Ministry of Construction Materials, State Design Centre for Machine Building of the USSR Ministry of Road Construction and Construction Equipment Machinery, Central Research Institute of Housing Engineering Design of the USSR State Committee for Construction, and also by numerous design-engineering offices, experimental design offices (EDO) of a number of the USSR Construction ministries and departments. The modernization of prefabricated reinforced concrete enterprises made it possible to raise labor productivity by 2 – 2,5 times, to ensure 10% cement saving and to reduce construction prime cost.

The author took an active part in numerous research and technological directions i.e. creation of new casting equipment, extensive use of various chemical and mineral agents in concrete mix composition, creation of new technological lines as well as the development of environmentally friendly materials and comprehensive concrete utilization after the end of its working life. Being in charge of the research in the field of reinforced concrete technology in the system of Head Department for Construction Materials and Details Industry of Moscow City Executive Committee, Concrete and Reinforced Concrete Research Institute of the USSR State Committee for Construction, the author was one of the leading experts on technical reequipment or retooling of prefabricated concrete industry.

The practice of the reequipment of prefabricated reinforced concrete industry in 1981 – 1990 will be helpful for employees of the construction materials industry, designers, construction workers and, in particular, professors and students of engineering qualifications.

PREFABRICATED REINFORCED CONCRETE INDUSTRY IN 1981 – 1985

The challenge set by the governmental agencies to speed up socio-economic development for 10-15 years coincided with the period of demographic change when for the first time ever the USSR had to increase public production by means of labour intensification and increase in labour productivity. For example, in 1976 – 1980, the growth in labor force made up 11 million people; in 1981-1985 it made up 3 million people, in the 86-90s, the growth made up a little more than 1 million people.

The governing factors of the increase in labour productivity and in production of a gross national product were considered to be hand labour reduction, mechanization, automation and robotization of the production, the improvement of management structures, development and introduction of economic instruments and incentives. This challenge was also currently central for the industry of prefabricated reinforced concrete which is still considered to be one of the primary sectors of the construction industry base.

Prefabricated reinforced concrete was and will be in the long term the main construction material. The industrial dynamics of prefabricated reinforced concrete in terms of output and assortment is presented in tables 1 – 4.

Table 1

Output of prefabricated reinforced concrete
in respect of the types of articles and structures until 1990 (million m^3)

Articles and structures description	1985	1990	Estimates for 1995
1	2	3	4
Total across the USSR:	136,0	143,0	151,0
including: 1.Footings,	12,1	12,4	12,9
among them: piles	6,0	6,3	6,7
of which: without lateral reinforcement	1,4	2,4	3,6
jointed piles	0,2	0,4	0,9

1	2	3	4
2.Building frame including:	13,8	14,3	14,5
a) uprights of frame and columns, of which:	6,5	6,7	6,8
centrifugal columns	0,05	0,09	0,14
b) collars, beams, trusses, of which:	7,3	7,6	7,7
made of high-strength concrete	0,8	1,1	1,5
3. Walls and construction units (stair flights, staircase landings, lintels, utility room panels), including:	38,5	42,1	48,2
a) external wall panels	26,4	28,0	32,4
б) internal walls and partitions among them:	11,5	13,2	14,4
ready-to-use partitions	2,7	3,7	5,0
c) building block module	0,6	0,9	1,4
4.Roof slabs, among them:	13,5	14,1	14,2
a) tridimensional ones	0,6	1,7	2,1
b) span ones	0,5	0,8	1,8
c) composite ones	1,5	1,8	2,2
d) non-roll roofing panels	0,13	0,14	0,15
5. Engineering structures items	9,5	9,9	10,2
6. Floor slabs, including:	33,5	33,8	32,6
multi-hollow slab	15,0	15,9	15,9
7. Units for transport and communication facilities	2,9	3,3	3,6
8. Special reinforced concrete, including:	7,6	9,1	10,6
pressure pipe	0,67	1,41	1,91
non-pressure pipe	1,01	1,09	1,06
railway sleepers	1,06	1,14	1,17
special slabs	0,67	0,82	0,97
transmission towers	1,52	1,64	1,91
wall board posts	1,52	2,12	2,61
block-liners, pithead frame	0,68	0,77	0,85
posts for grassland	0,02	0,03	0,03
other items	0,05	0,06	0,09
9. Other structures	3,6	4,1	4,2

Table 2

Output of prefabricated reinforced concrete prestressed structures in terms of the types of structures and articles till 1990 (million m^3)

Structures description	1985	1990	Estimates for 1995
1	2	3	4
Total across the USSR:	29,0	36,0	41,0
1. Piles	1,9	2,4	3,0
2. Frame elements	4,8	5,7	6,0
including:			
beams and collars	4,05	4,8	5,0
crane beam	0,15	0,15	0,15
trusses	0,54	0,65	0,70
columns	0,06	0,10	0,15
3. Floor and roof slabs,	16,9	20,0	22,4
among them:			
multi-hollow ones	9,5	10,4	11,0
flat ones	0,6	0,7	1,10
ribbed ones	2,2	3,10	3,90
4.Elements of engineering structures	1,0	1,40	1,80
including:			
silo	0,3	0,5	0,60
Storage tanks	0,5	0,7	0,90
utility bridges	0,2	0,2	0,30
5. Special structures among them:	4,65	5,8	6,9
pressure pipes	0,97	1,41	1,91
sleepers	1,06	1,14	1,17
special slabs	0,67	0,82	0,97
power transmission towers, tie constructions	1,52	1,64	1,91
frame upright for grapevine trellis	0,2	0,69	0,74
pithead frame	0,08	0,10	0,20
6. Bridge span	0,35	0,50	0,70
7. Other structures	0,2	0,20	0,20

Table 3

Overall output of prefabricated reinforced concrete structures and articles made of lightweight concrete with the use of porous fillers until 1990 (million m^3)

Structures description	1985	1990	Estimates for 1995
Total across the USSR,	21,0	36,0	44,0
including:			
1.Walls and building units	10,7	17,0	19,8
2. Floor and roof slabs,	7,2	13,4	17,0
among them:			
roof slabs	3,7	6,8	8,7
floor slabs	3,5	6,6	8,3
3. Load bearing elements,	1,9	3,6	5,0
among them:			
columns	0,5	0,9	1.2
trusses, collars, beams	1,4	2,7	2,8
4. Transportation construction	0,3	0,7	0,8
5. Special reinforced concrete	0,24	0,5	0,6
6. Other structures	0,7	0,8	0,8

Tables 1–4 display that in 1985 the overall output of prefabricated reinforced concrete exceeded 136 million m^3 and in comparison with 1980 (122,5 million m^3) grew by 11,3%. By 1995, the overall output had to increase up to 160-162 million m^3 at an average annual growth 1,8%. In 1981 – 1985, the output of advanced structures practically didn't increase. By 1995, it was planned to increase the output of prestressed structures up to 47 - 48 million m^3 and structures made of lightweight and cellular concrete up to 61 million m^3.

Table 4

The use of prefabricated reinforced concrete structures and articles made of cellular concrete until 1990 (million m^3)

Structures description	1985	1990	Estimates for 1995
Total across the USSR, including:	4,23	6,33	8,42
wall panels and walling blocks	1,4	2,01	2,53
roof slabs, floor slabs and reinforced insulating boards of the roof slabs	0,34	0,5	0,65
one-hand blocks and partition panels	2,0	3,12	4,33
Other structures	0,03	0,04	0,07

In 1985, the main types of articles and structures made of prefabricated reinforced concrete were roof and floor slabs – 47 million m^3 or 34,8%, walls and other building units (external wall panels, internal walls and partitions, stair flights, lintels, etc.) – 38,5 million m^3 or 28,5%, frames of buildings – 13,8 million m^3 or 10,2%, footings – 12,1 million m^3 or 9% of the overall output.

The current use of prefabricated reinforced concrete in the listed below construction sectors is characterized by the following indicators (%):

– residential construction and civil engineering – 47

– construction of industrial, transport and communication facilities – 30

– agricultural (including water engineering) construction – 18

– full repairs and other needs – 5.

The consumption history of prefabricated reinforced concrete for 1 million rubles for construction and erection works is presented in table 5. It varies in the contract construction ministries and departments and depends on the construction and erection work structure, the level of wholesale prices and some other factors. So, in the USSR Ministry for the Oil and Gas Industry the consumption of prefabricated reinforced concrete for 1 million rubles for construction and erection work made up 510 m^3, in the USSR Ministry of

Transportation Construction – 960 m^3, in the USSR Ministry of Energy – 1225 m^3, in the USSR Ministry of Heavy Engineering – 2990 m^3, in the USSR Ministry of Construction, Architecture and Housing – 3075 m^3, and in the USSR Ministry of Industrial Construction it reached 3110 m^3.

Table 5

The consumption history of prefabricated reinforced concrete for 1 million rubles of construction and erection works

Years	The Scope of construction and erection work, total, billion rubles	Annual output of prefabricated reinforced concrete, million m^3	Consumption of the prefabricated reinforced concrete for 1 million rubles
1975	79,7	114,2	1433
1980	87,3	122,2	1400
1981	89,2	124,4	1395
1982	91,3	123,5	1353
1983	93,4	128,3	1374
1984	90,5	132,4	1462
1985	92,0	135,0	1467
1990	100,0	138,0	1380
Estimates for 1995	108,0	142,6	1320

In 1981 – 1985, this figure changed from 1400 up to 1467 m^3 on average and reached its height in 1985. The quantity of prefabricated reinforced concrete in the total amount of construction and erection works was rather high and made up more than 13%. In 1981 – 1985, there was neither an essential increase in labor productivity nor decrease in product labor consuming nor increase in technological level in the industry of prefabricated reinforced concrete.

By 1990, prefabricated reinforced concrete structures and articles were produced at about 6000 different enterprises (according to the Central Statistical Administration of the USSR), governed by nearly 60 ministries and departments. The capacity of prefabricated reinforced concrete plants made up 161 million m^3 of structures and articles a year (according to

Concrete and Reinforced Concrete Research Institute and All-Union Concrete and Reinforced Concrete Research Institute). The Plant concentration of prefabricated reinforced concrete is given in table 6 (according to the taken into account enterprises in total 2856 or 79% of overall output of prefabricated reinforced concrete).

From the data presented, one can see that there were a large number of small enterprises in the industry. They made up 31,8%, and the annual output of prefabricated reinforced concrete made up 6,4%. The total number of small enterprises with the capacity up to 5 thousand m^3 a year exceeded 500 and kept multiplying. The main reason for this growth was departmental disunity in the issues of "own" capital construction with the use of prefabricated reinforced concrete structures and articles of a wide assortment as well as the creation of automated enterprises of small capacity for small-size articles according to the rotary scheme which was offered with the author's participation.

Table 6

Plant concentration of prefabricated reinforced concrete production

Plant capacity, thousand m^3	Number of plants, final %	Annual average capacity, final %	Output of reinforced concrete articles, final %	Output of reinforced concrete articles at a plant, thousand m^3
Up to 5	8,7	0,6	0,6	3,6
5-20	23,1	5,4	5,8	12,9
20-60	28,0	16,9	16,9	33,1
50-100	25,3	33,8	32,1	72,0
100-150	8,8	19,2	19,1	120,0
150-200	3,5	II,I	II,4	172,7
Over 200	2,6	13,5	14,1	284,7
Total:	100,0	100,0	100,0	23

The enterprises with the capacity ranging from 20 to 100 thousand m^3 made up 53,3%, with annual output 49% of total amount. Productive capacity of the prefabricated reinforced concrete industry is mainly concentrated in Central, Volga, Donetsk-Dnieper, Northwest and Ural economic zones (table 7). There used to be 40% of the productive capacity, and in Eastern Siberia as well as in the Far East - 11% of the capacity.

The industry had the equipment of about 5 million tons, including metal moulds with an overall mass of 2,6 million tons. The capital funds of prefabricated reinforced industry made up 13 billion rubles, including the equipment - 4 billion rubles or 30%.

The analysis shows that for 1981 - 1985 the cost of capital funds raised by 33,3% in case of the increase in output by 10,5%. The productive capacity of the industry for the same period increased by 7,3%. It means that the increase in production was mainly carried out on an extensive developmental pattern, due to the start-up of new enterprises the capacity of which was being slowly developed. Capacity utilization coefficient for 1981 - 1985 increased only from 0,8 up to 0,84.

Table 7

Current capacity for prefabricated reinforced concrete plants, 1985 output and capacity utilization

Land area	Capacity for 01.01.85, thousand m^3	Annual average capacity, thousand m^3	Output, thousand m^3	Capacity utilization, %	Overall output (according to the USSR CSA), thousand m^3
1	2	3	4	5	6
USSR	142098,8*	138846,4*	110741,5*	79,8	132425,4**
Russian Soviet Federative Socialist Republic	82461,8	80410,7	63218,8	78,6	69736,5
North region	3516,1	3502,3	2854,2	81,5	3067,6
Northwest region	5448,5	5445,1	4124,1	75,7	4473,8
Central region	19047,3	18750,4	15158,1	80,8	16069,7
Volga-Vyatka region	3986,6	3819,6	2959,4	77,5	3497,0
Central Black Earth region	3797,8	3775,8	2694,8	71,7	3358,6

1	2	3	4	5	6
Volga region	9756,0	9651,8	7792,3	80,7	8891,5
North Caucasian region	6638,1	6541,4	4978,6	76,1	5823,7
Ural region	10934,7	10818,4	8765,1	81,0	9395,5
West-Siberian region	8650,9	8371,6	6415,1	76,6	6991,3
East-Siberian region	5104,9	4906,1	3735,2	76,1	3894,7
Far East region	5196,5	4431,8	3460,1	78,1	3858,6
Kaliningrad region	384,4	394,4	281,8	71,4	333,3
Ukranian SSR	22720,4	22105,3	18832,1	85,2	21197,2
Belorussian SSR	5716,1	5533,8	4871,3	87,7	5744,1
Uzbek SSR	6870,1	6843,2	5043,8	73,7	5766,4
Kazakh SSR	0192,6	7977,1	6009,7	76,3	6270,6
Georgian SSR	2169,9	2137,4	1618,8	76,7	1868,8
Azerbaijanian SSR	2397,5	2553,3	1671,6	66,5	T941,9
Lithuanian SSR	2170,4	2168,1	1926,6	88,8	2255,4
Moldavian SSR	1782,0	1763,9	1416,7	80,3	1652,6
Latvian SSR	1541,7	1501,7	1312,4	87,3	1510,7
Kirgiz SSR	1047,6	1029,3	864,2	84,0	988,3
Tadzhik SSR	1288,1	1214,1	942,5	77,6	1056,5
Armenian SSR	1547,7	1490,8	1265,5	84,8	1364,3
Turkmen SSR	1182,6	1119,6	867,9	77,5	953,0
Estonian SSR	1010,3	998,1	880,3	88,2	958,7

* the capacity of the USSR Ministry of Defence and intereconomic organizations isn't included here,
**Among them: the USSR Ministry of Defence – 3956,7; Glavspetsstroy at USSR Ministry of Erection and Special Construction Works – 1280,5; others – 3 903,8 thousand m^3.

In the industry of prefabricated reinforced concrete for the beginning of 1985 there worked 10082 flow-line systems, 674 conveyor lines and rolling mills, 5906 battery-mold installations, 8218 stands, about 50 thousand of curing rooms including automated and semi-automated and 400 tunnel ones. A great part of the output (63%) was issued on flow-line system with thermal treatment in rooms of a pit type.

Capital/labour ratio increased from 24,3 thousand rubles of the capital equipment per 1 unit of labour in the largest shift in 1980 up to 30,7 thousand rubles in 1985 or for 26%. The calculations show that one percent of capital/labour ratio growth frees 0,2 - 0,25 people. The level of mechanization increased from 1981 to 1985 from 7,3 to 8,6 thousand rubles of active parts of the capital equipment per 1 unit of labour in the largest shift (in case of shift index 1,48), i.e. for 18%.

The return on investment as a fund creating ratio characterizing the process utilization grew from 0,74 rub per 1 ruble of the capital equipment up to 0,78 ruble, i.e. for 5,4%. At the same time, this growth can't be taken entirely for the improvement of capital equipment as in 1981 – 1985 there was an increase in wholesale prices and tariffs in the industry. Just in the industry of prefabricated reinforced concrete the increase in wholesale prices made up 17 – 27%. Taking into account the above stated, it is possible to draw a conclusion that, in fact, the process utilization didn't improve in the sector.

The capital intensity of the production of prefabricated reinforced concrete increased from 80 to 96 rub./m^3, i.e. for 20%, which shows the increase in specific capital expenditure for the production of prefabricated reinforced concrete. The technical level of the enterprise is characterized by the amount of the capital equipment per 10 units of labour and makes up from 1,1 up to 1,7 units, whereas, at the advanced enterprises it makes up from 2,4 to 3,2 units. The basic amount of reinforced concrete articles – 72% of the overall output is made at the flow-line system, about 12% at the battery-mould installations, 9% at conveyor ones and 7% at bench lines.

The capacity factor which is the output of prefabricated reinforced concrete per 1 unit of labour increased from 203 m^3 in 1980 up to 219,6 m^3 in 1985, i.e. for 8,2%. The challenge to raise labor productivity in 1981-1985 in the industry of prefabricated reinforced concrete remained actual. The data on the average output per 1 unit of labour at the enterprises of the construction ministries are given in table 8.

Table 8

The average output of reinforced concrete articles per one worker in the USSR ministries and departments and best-practice labour productivity for 1985

Ministry (department)	Output per one worker, m^3
Total across USSR	219,6
Local councils, among them:	270,0
Head Department of Construction Materials and Products Industry of Leningrad City Council	274,0
Reinforced Concrete Plant # 6	310,0
Reinforced Concrete Plant #19	348,0
Plant «Molodoy Udarnik»	484,0
Head Department for Construction Materials and Details Industry of Moscow City Executive Committee	340,0
Reinforced Concrete Plant #3	509,0
Reinforced Concrete Plant #4	462,0
Reinforced Concrete Plant #5	531,0
KIEVGORSTROYMATERIAL	256,0
USSR Ministry of Energy	205,0
Novospassky Reinforced Concrete Plant	437,0
USSR Ministry of Oil Industry	195,0
USSR Ministry of Oil Refining and Petrochemical Industry	146,0
USSR Ministry of the Gas Industry	262,0
USSR Ministry of Heavy Engineering	227,0
USSR Ministry for Construction Materials	253,9
Kalinin Construction Materials Factory#2	379,0
Grodno Construction Materials Factory	794,1
Karaganda Reinforced Concrete Plant	426,0
Temirtay Factory «Promstroiindusriya»	518,0
Pavlodar Reinforced Concrete Factory	578,0
USSR State Agriculture Committee (former Ministry of Agriculture)	259,1
Podolsk Experimental Factory of Construction Structures	537,0
Yaroslavl rural building factory	433,3
USSR Ministry of Water Administration	179,0
Chardarinsk KSM	488,0
Irkutsk Reinforced Concrete Factory	423,0
USSR Ministry of Heavy Engineering	219,0
Construction yard "Achinskalumiystroy"	727,0

Shadrinsk Reinforced Concrete Plant	577,0
Reinforced Concrete Plant of the multicorporate enterprise "Orenbyrgzhilstroy"	539,0
USSR Ministry of Industrial Construction	218,5
Onega Reinforced Concrete Plant #4	426,4
Gurov Reinforced Concrete Plant	399,6
USSR Ministry of Construction	223,2
Barnaul Cellular Concrete Plant	854,0
Arzamass KPP #4	604,0
Novosibirsk Reinforced Concrete Plant #12	417,1
Engels Reinforced Concrete Plant #3	591,4
Yaroslavl Reinforced Concrete Structures Factory	514,6
Vilnius Reinforced Concrete Plant #3	327,9
KPP Daugavpils	554,1
USSR Ministry of Transport Construction	195,7
Novoaltaisk Reinforced Concrete Plant	324,0
Voronezh KSM	374,5
Dnepropetrovsk KPP	374,6
USSR Ministry of erection and special construction works	223,2
Usol Plant of Reinforced Concrete Piles	384,6
USSR Ministry of Construction for the Eastern Regions	181,5
Large-panel housing-25 of Vladivostok Integrated Home-Building Factory	360,8

At average annual growth rates of capital/labour ratio 5,2% of the increase in effectiveness in 1981-1985 made up 1,6%, i.e. the capital/labour ratio grew by 3,3 times quicker than its productivity. The obsolescence and depreciation of the equipment greatly influenced capital/labour ratio and labor productivity.

The research conducted at Concrete and Reinforced Concrete Research Institute and All-Union Concrete and Reinforced Concrete Research Institute at the enterprises of prefabricated reinforced concrete shows that according to its service life the production machinery is classified as follows: up to five years – 36%; from five to ten years – 27%; from ten to fifteen years – 14% and more than fifteen years - 23%. The analysis of the age composition of the equipment at the enterprises producing prefarbricated reinforced concrete made it possible to establish that 37 % are in operation over ten years.

According to current depreciation standarts, the service life of production machinery is from four to ten years. About one third of the production machinery at the enterprises which manufacture prefabricated reinforced concrete articles is used after the end of its service life. Equipment handling for two and more service life terms (in comparison with the standard) results in full repairs more than seven times according to fixed interrepair time. The provided data can also be referred to the prefabricated reinforced concrete industry. The handling of obsolescent and worn-out equipment at the enterprises which produce prefabricated reinforced concrete articles leads to extra expenses for technological service, technical maintenance and full repairs. Besides, due to its poor reliability, as a rule, the equipment stands idle due to the failures for the period of a greater regulatory time limit. It has an adverse effect on production efficiency and quality of produced articles.

The undertaken study and the analysis of obtained results make it possible to conclude that the expenses for technological service and technical maintenance in case of operation in the second repair cycle comparing with the first one increase for 10-15%, in the third one for 20-25% and in the fourth cycle for 28-35%, and the expenses for full repairs keep growing. So, for example, the first full repairs make 28% of the cost of the new equipment, and the second is about 52%. The current age assortment of manufacturing machinery at the enterprises of prefabricated reinforced concrete is the result of industrial underdevelopment of manufacturing equipment. Its developmental level lags behind the requirements of the enterprises producing prefabricated reinforced concrete.

Almost one fifth of all technological equipment has limit-exceeding noise, vibration, dust and moisture level. The noise level in reinforced concrete factory floor exceeds the limit (in decibels) for 30-40% and covers about 25% of total number of workers.

Vibroplatforms, attached vibrators, pneumatic actuators, concrete mixing and compacting machines are the major noise and vibration makers. The workers of the majority of concrete batching plants and cement bulk storages are exposed to high level of cement dust which exceeds the limit of 30%. Due to technical failures and improper operation of curing rooms, the excessive level of steam generation in casting floors results in limit-exceeding air moisture and increase in cold-related diseases of workers in casting floors.

A large part of the equipment produced by the machine-building industry has dangerous sharp edge corners, irregular surface, no protection, and etc. According to sociologists, the elimination of the abovementioned factors could provide the raise in labor productivity for 20-30%.

The downtime of equipment reduces labor productivity. In particular, in 1985, the downtime of conveyor and bench lines made up 19%, flow-lines 16%, rolling mills 20%, battery-mould installations 22%. Losses in labor productivity due to over-plan downtime of the equipment make up at least 4-5%. In 1985, the number of operation personnel increased from 725 to 760 thousand people or for 4,8%, including workers from 602 to 634 thousand people or for 5,3%.

According to the research data of Concrete and Reinforced Concrete Research Institute and All-Union Concrete and Reinforced Concrete Research Institute, up to 40% of the total number of workers in the sector, i.e. about 250 thousand people are occupied in to different extents with hand-labour. Of this amount over 60% are involved in the principal technological processes whereas the others carry out auxiliary work. The most labor-consuming operations should be carried out in the process of manual cleaning of concrete mixers, cleaning and greasing of moulds, introduction of reinforcement and mortgage details, finishing of products, inward flanging of moulds and some other works. In the process of cargo handling the substantial part of labour falls on slinging and unslinging.

A considerable part of hand-labour falls on provision and storage operations. Thus, despite rather high level (about 80%) of mechanization, the processes of processing cement in storages as well as vehicles stripping, discharging of the together frozen bulks, controlling the amount of agregates and cement were not mechanized.

A considerable amount of manual labour falls on reinforcing operations. Suffice to say that of the total number of the regular and auxiliary workers about 17% are involved in the production of reinforcing details, of them 41% work by hand. Mechanization level in assembly floors makes up 55%, and in the floors of the small capacity 18-22%. Characteristic features of today's production of a reinforced unit are considered to be its wide assortment, lack of specialization, separation of the technological process into a number of consistently carried out operations as well as great specific weight of the outdated equipment.

Meanwhile, there is a vast experience of the leading enterprises where the majority of the above-mentioned operations are successfully mechanized. The branch level of mechanization averages about 60%.

The structural analysis of the operation personnel according to occupational structure shows that of the total amount of employees (760 thousand people) workers make up 83% or 634 thousand people, among them 60% or 380 thousand people are the regular workers and 40% or 254 thousand people are auxiliary ones. In the total number of regular workers steel erectors make up about 32 thousand people; electric welders of grids and frames 65 thousand people; batchers 15 thousand people; crane operators 35 thousand people; mechanics for concrete mixers, transfer carts, and etc. 38 thousand people; operators 7 thousand people; moulders 144 thousand people; riggers 8 thousand people; finishers 10 thousand people; workers of other professions 26 thousand people.

Table 9 presents data on the structure the mechanized and manual operations in factory production of prefabricated reinforced concrete.

Table 9

Description	Personnel ratio, %	
	mechanized	manual
Core operations		
Concrete mix preparation and its handling to casting room	80	20
Production of reinforcement	59	41
Casting of products	62	38
Auxiliary operations		
Mechanical-repair department	35	65
Intradepartmental materials handling	26	74
Store handling and operations	52	48
Storing of end products	84	16

The results of the analysis showed that the main labour resources are mainly concentrated at the processes of products casting, production of reinforcement, finishing of manufactured articles and in auxiliary production. The examination of prefabricated reinforced concrete enterprises conducted in 1981-1985 in order to identify in-shift losses of working hours diagnosed the following losses (table 10).

Table 10

Factors for losses	Losses, **%**
Technical failure, unscheduled repairs of the equipment, engineering set up, adapting of the equipment	42,7
Lack of materials, details, subproducts	28,6
Lack of engineering documentations, tools, energy	9,0
Leaving work place with administrator permission	8,4
Arriving late at work, early end of working hours, downtime caused by the workers and etc.	11,3
Total	100,0

The analysis of table 10 shows that the greatest losses are connected with technical failures of the equipment and late delivery of raw products and materials. The greatest losses of working hours in the main production (concrete mixing department, reinforcing, casting processes) appear because of the failures in auxiliary services – mechanical and repair, electric power floor.

A detailed analysis of in-shift losses in working hours in the main production made it possible to establish that 40% of all downtime was caused by service repairmen; 25% of downtime is caused by failures of storage-retrieval workers.

About 17% of all the workers are management personnel. At a number of the enterprises the percentage of auxiliary staff and management personnel exceeds average level across the sector by 1,5 – 2 times. In reduction of the administrative and managerial personnel there are also hidden many resources. For example, Quality Department in the total number of administrative and managerial staff at Concrete and Reinforced Concrete Plants reaches 10%. The automation of quality control will make it possible to free at least 4-5 thousand employees of laboratories and

Quality Departments. The automation and computer application in accounting and scheduled calculations will also make it possible to free administrative and managerial staff.

On the one hand, there is a broken relation between the quantity and quality of work in construction sector, and on the other hand in the level of its norming. In this regard, there functions a schedule system when the wages fund is fixed at the enterprises according to the number of involved people and their average salary, without taking into account labor-consumption for production. The outdated system of base salaries which is not adequate for the scheduled pay level breaks the rules of work standardizing. The fourth category of workers is known to be the average category across the sector. These are 63,7 kopeks an hour or 93 rubles a month, i.e. workers have to carry out 2 performance standards a month to have an average salary of 180 rubles per month. Such norms are very far from the technically based standards.

In 1981-1985, along with low growth rates of labor productivity there was a significant increase in product cost for $1m^3$ of reinforced concrete from 59,1 to 68,9 rub/m^3 i.e. for 16,5%. Thus, the wholesale price increased from 59,2 to 75,5 rub/m^3, i.e. for 27,5%. To a great extent, it is connected with the improvement in the wholesale prices and tariffs carried out in 1982. The carried-out improvement in the wholesale prices for prefabricated reinforced concrete articles made it possible to raise the level of profitability in the sector – from 0,2% in 1980 to 9,6% in 1985, however, the achieved level was much lower of the standard one (15%). Profitability of the prefabricated reinforced concrete production had a reducing trend.

The factors connected with the increase of ready-to-use products in order to raise work labor input at Concrete and Reinforced Concrete Enterprises have considerable impact on dynamics of labor productivity in the industry of prefabricated reinforced concrete. Incomplete data of the Central Statistical Administration of the USSR indicates that the percent of a more labor-consuming production increased on the average for 1 million m^3

a year which reduced the growth rate of labor productivity approximately for 30% across the sector.

As for the industry of a large-panel housing construction, according to the Central Scientific Research Institute for Experimental Housing Design, by the end of 1985 the industrial base of prefabricated construction (Large-panel housing construction + block housing construction) was made up of 545 enterprises (Integrated home-building factories, Rural building factories, plants and floors of large-panel housing) with a general capacity of 63 million sq.m a year.

The dynamics of the change in the fabrication yard for 1981 - 1985 is presented in table 11.

Table 11

Fabrication yard of prefabricated construction	1981 – 1985				
	1981	1982	1983	1984	1985
Number of enterprises	493	504	516	545	545
Capacity, million m^2 of the total area	54,9	58,754	59,529	62,479	63,0
Process utilization, *%*	77	77	79	79	79

The analysis of the state and process utilazation for 1984 shows that 48% of the enterprises of prefabricated construction used capacities below the industry average level. Especially poor were used the capacities of such enterprises as the USSR Ministry of Farm Building, the USSR Ministry of Petroleum and Gas Production, the USSR Ministry of Water Administration where the use of capacities in 1984 made up: 60, 64, 67, 64, 54%.

At the same time, a number of the ministries and departments used the current capacities rather effectively. Among them (as of 01.01.1985), first of all, should be noted the USSR Ministry of Industrial Construction (85%), Glavmosstroy (95%), Head Department for Construction Materials and Details Industry of Moscow City Executive Committee (97%), Glavkiyevgorstroy (94%), Glavalmaatastroy (100%). Operating experience and achievements of the abovementioned ministries and departments testify to the possibility of achieving a higher utilization process comparing with the average one. It also testifies to the available resources to intensify the production at the operating enterprises of prefabricated housing construction.

Slow development of capacities at the enterprises being under reconstruction led to the decrease in coefficient of their use. It has an adverse effect on business economics, results of their organizational economic activity: the fixed business assets grow and capital productivity decreases, prime cost and expenses for one ruble of production as well as work labor input increase. About 60% of large-panel construction capacity is concentrated at integrated home-building factories. The capacity and a number of rural building factories increased.

The average capacity of the enterprises of prefabricated housing construction makes up 115 thousand m^2 of total area. Of the total number of the enterprises 157 (29%), mainly floors, have the average capacity of 33 thousand sq.m of total area. Only 73 enterprises (13%), mainly integrated home-building factories, have the average power of 331 thousand sq.m of total area.

Equipment deterioration is considered to be one of the factors retaining utilization process of material and technical resourses. The enterprises of housing construction are equipped with obsolete facilities. Specific weight of the technological equipment with service life up to 5 years is 33%, 5-10 years - 49%, 10-20 years - 17%, more than 20 years - 1%, the same situation with metal casts: up to 5 years – 46%, 5-10 years - 51%, 10-20 years - 3%.

The industry average indicators at the enterprises of prefabricated housing construction for the end of the 80s:

- metal consumption - 30-35 kg/sq.m of total area a year;
- cement consumption - 300-350 kg/sq.m of total area;
- capital productivity ratio - 0,6-0,8 rub/rub;
- prime cost - 50-53 rub/sq.m of total area;
- the cost of the fixed industrial and production capital equipment - 72 rub/sq.m of total area.

At the same time, at 60% of the enterprises the cost of the fixed business capital equipment by two and more times exceeds the standard value of 60-65 rub/sq.m of total area in a year. Only 25% of the enterprises have capital productivity more than 1 rub/rub. On the basis of the leading enterprises of large panel housing there were created the first exemplary integrated home-building factories.

Table 12

Basic technical and economic indexes of integrated home-building factories operation in 1985

Indexes	Unit of measure	Tallinn	Gatchina	Kalinin (Tver)	Naberezhnye Chelny	Vladivostok	Belotserkovsk	# 1 Donetsk Integrated home-building factory
Capacity	Thousand sq.m of total area	208	300	300	540	264	114,6	200
Residential houses supply	Thousand of sq.m of total area	221,9	319,9	144,6	393,6	192,5	114,6	170,4
Labour input (factory)	$\frac{\text{mhrs}}{\text{m}^2}$ of total area	4,4	5,2	7,36	16,8	7,12	6,4	8,1

Among them integrated home-building factories of the USSR Ministry of Construction, Architecture and Housing (Tallinn, Kalinin, Gatchina), the USSR Ministry of Energy, the USSR Ministry of Construction for the Eastern Regions of the USSR (Vladivostok), Ministry of Industrial Construction of the Ukranian SSR (Belaya Tserkov), Ministry of Heavy Engineering of the Ukranian SSR (Donetsk, No. 1 Integrated home-building factory). The main technical and economic indexes of these enterprises are given in table 12.

2. THE ANALYSIS OF NEW TYPES OF STRUCTURES DEVELOPED IN 1981 – 1985 AND THE EFFICIENCY OF THEIR USE IN 1986 - 1990

Prefabricated concrete and reinforced concrete structures are considered to be the main structures for mass construction. The USSR has the world lead in their application. In 1995, the overall production of prefabricated concrete and reinforced concrete structures had to make up 151 million m^3 (table 13).

Table 13

Overall application of prefabricated concrete and reinforced concrete up to and including 1990 (million m^3)

Type of concrete and reinforced concrete	1985	1990	Estimates for 1995
1.Prefabricated reinforced concrete,	136	143	151
including:			
prestressed	29,0	36,0	41,0
lightweight based on porous aggregates	21,0	36,0	44,0
cellular	4,0	6,0	8,0
2. Prefabricated concrete,	15	16	16
including:			
blocks for basement walls	4,2	4,3	4,3
wall blocks	1,6	1,3	1,0
roadstones	7,7	8,8	9,2
walkway slabs	0,8	0,6	0,5
other articles	0,8	1,0	1,0
Total: Prefabricated concrete and reinforced concrete	151	159	167

According to Concrete and Reinforced Concrete Research Institute, in 1990 and 1995, the anticipated output of prefabricated structures had to make 159 and 167 million m^3 with the increase in comparison with level of 1985 for 6 and 11%. Moreover, effective types of reinforced concrete structures i.e. prestressed ones and structures made of lightweight and cellular concrete were supposed to be developing at higher rates. For example, by 1990, the production level of prestressed structures in comparison with level of production of 1985 (29 million m^3) increased for 24%, structures made of lightweight concrete (21 million m^3) for 72%, structures made of cellular concrete (4 million m^3) for 50% which makes it possible to receive the general economic benefits of 325 million rubles, to save up 240 thousand tons of steel (in natural calculation), 1170 thousand tons of cement and figuratively free 9 thousand workers. The structure of application of reinforced concrete structures was supposed to be significantly changed by increasing specific weight of the most functional types of structures.

For example, in case of not very large general growth in volumes of structures (the growth by 1990 in comparison with 1985 of 7 million m^3 or 5%), *the increase in production of piles without lateral reinforcement will make up 71%, jointed piles 100%, centrifuged columns 80%, bearing structures made of high-strength concrete 37%, partitions of a full factory readiness 37%, three-dimensional roofing 180%, span slabs 60%. According to the enlarged assortment, by 1995, it was expected to increase the production of walls and partitions up to 40%, special reinforced concrete up to 50% by increasing the production of pressure pipes, power transmission towers and wall board posts (see table 1).*

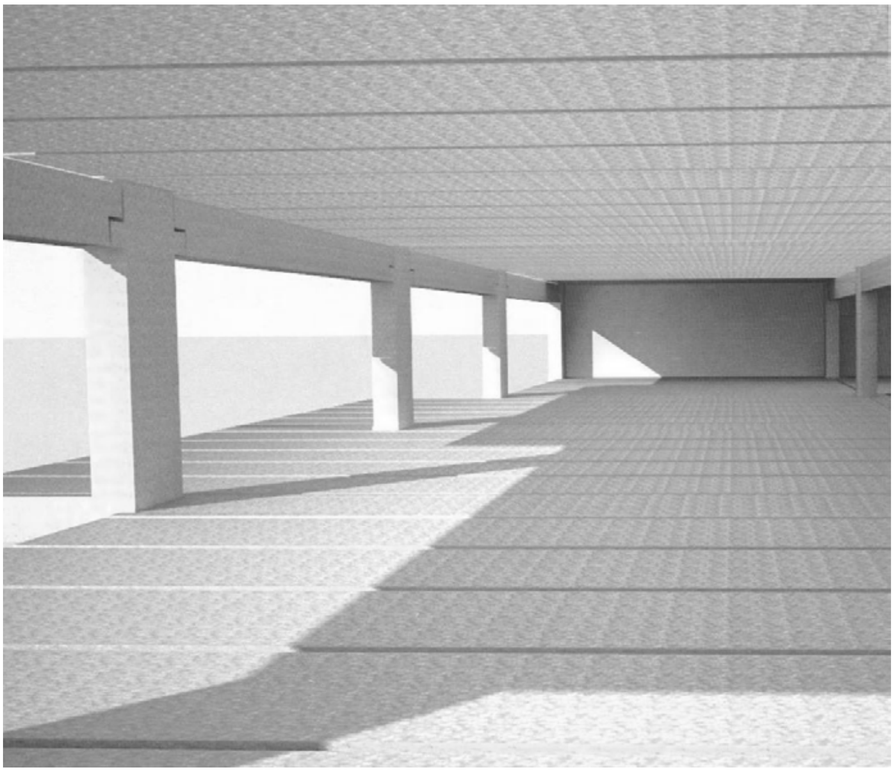
In 1981-1985, the output of prestressed structures had to increase up to 35-36 million m^3. By 1990, in the structure of prestressed items the specific weight of floor and roof slabs had to make up 55%. The use of prestressed structures makes it possible to gain economic benefit from 0,8 up to 4,5 rub./m^3.

By 1990, in the structure of lightweight concrete items the specific weight of wall panels had to make up 47%, roof and floor slabs 37%. In production of the enclosure structures made of lightweight concrete the limitation of volume weight up to 1100 kg/m^3 made it possible to provide viable resistance to a heat transfer of designs for many regions of the country without the increase in their thickness. The economic benefit of the use of lightweight concrete varies from 2 to10 rub/m^3 depending on the purpose of the structures, the type of lightweight concrete and the area of construction.

Having the current structure of production and use of lightweight concrete the average economic benefit across the country can be taken at about 3,9 rub./m^3. In the structures made of cellular concrete the specific weight of wall panels had to make up 35%, wall blocks and partitions slabs 50%.

The modern/current level of development of reinforced concrete theory provides an opportunity to create new advanced structures surpassing the best foreign samples in technical and economic indexes. The main requirements imposed to reinforced concrete structures for providing a high technological level of construction are considered to be the decrease in material consumption, labor intensity and costs due to the use of high-strength, lightweight and cellular concrete, improvement of constructive decisions, decrease in steel consumption, increase in factory readiness, reduction of a number of assembly items on the basis of the enlargement of elements of prefabricated structures.

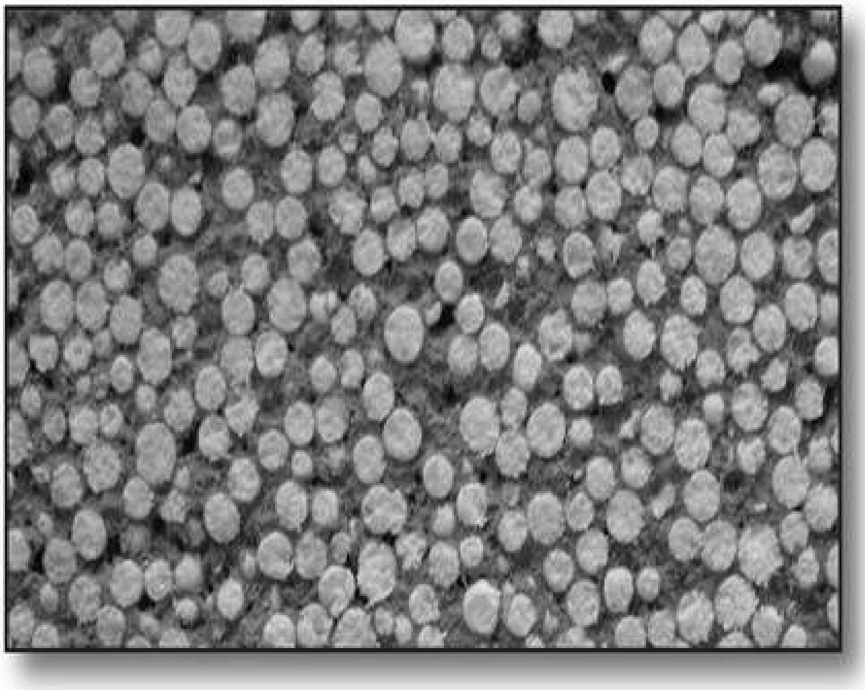
In the USSR there was developed a wide assortment of structures which meet these requirements, however, the construction ministries when working out plans to introduce new equipment annually reduced the amount of advanced structures. For example, in 1985, in the USSR Ministry of Industrial Engineering and USSR Ministry of Farm Building there were manufactured enlarged wall panels of full factory readiness made of lightweight concrete of 5 thousand sq.m in case of rational area of use for such panels i.e. 250 thousand sq.m a year. Losses in labor input due to a slow rate in production of these functional structures make up annually about 50 people - years. The production of KZhS and P span slabs at the enterprises of the construction ministries made up 0,3 million sq.m whereas their application is economically feasible on the area of 2 million sq.m a year. Here also decreases a possibility to reduce labor input for 850 people/year. Considerably from 8 to 15 million sq.m a year there has to be annually increased the application of complex slabs, panel partitions from 0,5 up to 6 million sq.m which will make it possible to save on labor input of about 8,2 thousand people/years. In 1990, the anticipated application of new functional reinforced concrete structures could make it possible to save on labor input of about 50 thousand/years (table 14).



1. Frame system in construction

2. Frame and Monolithic (block) construction

3. Blocks made of cellular concrete with foam polystyrene



4. Crosscut of a block

Table 14

Anticipated application of new functional reinforced concrete structures for 1990

Structures (functional)	Alternative	Annual output, million m^3	Economic benefit for a unit of measure			
			Steel, thousand tons	Cement, thousand tons	Labour input, people-years	Fixed charge rate, million roubles.
1	2	3	4	5	6	7
Self-stressed structures, including panels for non-roll roofing	Structures based on Portland cement	3,7	-	-	-	51,5
Prestressed large-sized roof slabs for spans 12 m and higher of full factory readiness	Roof slabs of factory readiness	2,0	68,6	58,0	1,1	92,4
Prestressed hollow-core floor slabs with lightweight functional reinforcement	Slabs with traditional reinforcement	8,4	6,8		0,2	3,0
Prestressed structures with continuous reinforcement	Floor slabs with high-tensile wire	1,5	3,2		0,5	1,2
Reinforced concrete structures made of concrete grade B45 and higher	Structures made of concrete grades B30-B40	5,4	90,1	56,3	5,1	18,7
Reinforced concrete structures made of fine grain (sand) concrete with cement consumption	Structures made of fine grain concrete with high cement consumption	17,2	-	100,0	-	4,7

Prefabricated reinforced concrete structures with low metal-intensive joints	Structures on current standard plan (1.420-12,II-04)	5,7	71,4	-	2,2	27,3
Reinforced concrete structures of ring cross section (columns, power transmission towers,piles and etc.)	Structures of rectangular cross section	1,0	91,0	68,2	2,0	42,5
Bearing reinforced concrete structures and articles made of lightweight concrete of 200-400 grade with the density of 1700 kg/m^3	Structures made of heavy concrete	12,6	0,3	15,0	-	2,1
Enclosure reinforced concrete structures and articles made of lightweight concrete with the density of 900 kg/m^3 and lower	Enclosure reinforced concrete structures and articles made of lightweight concrete with the density of 1100 kg/m^3 and higher	5,2	20,0	-	0,7	2,6
Panels and blocks made of porous arbolite	Structures and articles made of arbolite with the density of 800 kg/m^3	2,0	10,4	-	-	5,8
Enlarged (up to 6 m) external lightweight wall panels of higher factory readiness	Panels of small-piece bond	1,3	1,87	-	-	0,7

Multicore (double-layer and sandwich) wall panels made of lightweight concrete, including heat insulation	Single-layer panels	4,0	2,8	61,0	-	5,20
Enclosure structures made of high-strength autoclaved aerated concrete with the density of 600-700 kg/m^3	Structures made of cellular concrete with the density of 800-900 kg/m^3	1,75	3,2	-	-	5,3

Note: Annual saving on labour input according to the implementation scope – 50 thousand people/years.

In terms of materials consumption, as a rule, the structures of domestic production are more cost-effective than foreign ones, however, in terms of labour input they are often inferior to them, generally because of insufficient technological effectiveness and a small output of some standard types. It is necessary carefully to select the structures for the all-union assortment. Among current standard plans there are structures of the same purposes. It includes trusses with and without diagonal web, I-shape and lattice beams, span slabs of KZhS and P types.

When designing, the structures are often chosen according to only one criteria, for example, according to metal consumption or labour input on a building site. Consequently, roof girders are used in roofing of industrial buildings in more than 50% of the cases, though the technologically necessary area of their application makes up only 14%. Labor input for trusses is higher than for beams approximately by 1,5 times, and the materials consumption is almost identical with beams taking into account the increase in height of walls.

In case of mass production of building elements made of reinforced concrete it is necessary to use steel for framework elements such as crane beams for example. Though metal consumption of reinforced concrete crane beams is twice less than of the steel ones, however, taking into account rails and details of their fastenings, the cost of reinforced beams is 1,6 times higher, labor input by 2,5 times, installation by 1,4 times. It is necessary to reconsider the appropriateness of wide use of reinforced concrete roof girders and crane beams which will make it possible to reduce the assortment of standard structures and to raise their output.

For the purpose of reducing the assortment of structures produced in each region, there was introduced a system of territorial catalogs which allowed to reduce the regional assortment in comparison with the all-union one by 3-6 times. It is necessary to reconsider the formation of territorial catalogs for which the baseline information is considered to be the need of structure sets for the construction volumes during validity period of the catalogs. The awareness of the needs and the selection of parameters for prefabricated reinforced concrete allows to reduce even more standard sizes and classes for each region.

In case of continuous operation and development of research rates as well as project works it is necessary to provide the revision of the catalogs (for example, once in 5 years) that will make it possible to make the best of the created processing equipment and metal casts. When reconsidering catalogs it is advisable to pay special attention to technological effectiveness of structures in order to decrease labor input and increase its productivity. When designing it is also necessary to consider the portability of structures, possibility of their full factory readiness and installation by blocks to reduce labor input and to increase productivity.

The span structure 18x18, 24x24 m mounted by the blocks assembled at the construction site from reinforced concrete frames made of high-strength concrete and wire rope reinforcement by continuous reinforcing can be taken as an example. Frames are transported by the packages. Non-roll roofing for residential buildings which make it possible to reduce labor input for roofing by 40% can be taken as another example.

The reduction of block types, standardization of their sizes or even abandonment of their use are considered to be the factors promoting increase in technological effectiveness of structures. The decrease in labor input of installation in some cases can be reached due to the refuse to use welded connection with transition to bolted joints or connection of elements by prestressed reinforcement. It is necessary to tighten the control of placement of structures in catalogs. Placed structures have to be adopted by basic plants of the ministries, have to represent specifications, drawings of trusses, calculations of wholesale prices, etc. Current assortment of standard structures for one-storey buildings includes about 110 standards.

To erect one-storey building of a certain height with a column grid it is usually enough to have about 10 standard sizes of prefabricated structures (columns, beams, slabs, walls out of those included in the assortment). The assortment reduction of standard structures has to proceed but without loss of their profitability, and mainly, by reducing parameters of building dimensions, minimizing the number of buildings with level difference, transition from lantern lighting to a skylight one, etc.

Further improvement and development of new forward-looking solutions for structures of one-storey fabrication buildings has to run in the following principal directions: the use of high-strength concrete and designing of structures with effective cross sections, accounting the collaboration of enclosure and bearing structures with their weight reduction, enlargement of enclosure structures, increase in degree of their factory readiness to reduce the amount of assembly units and of labor input on the construction site.

The foundations for columns have to be lightened by using pile footing with grillages. For spread foundation it is necessary to use lightweight structures, passing from massive elements to ridge, hollow and thin-walled systems.

The columns of one-storey industrial buildings can be considerably lightened. With the change-over to hollow and I-shape columns made of B45-B60 classes, the mass of columns and the amount of concrete will decrease up to 50%. Prestressing with the use of high-strength reinforcement will be applied to the columns with a high moment of flection. In case of a large number of details it is recommended to apply external reinforcement with steel rolling profiles which are used as effective reinforcement of columns and provide fastenings along the element length.

It is necessary to update prestressed structures of floor slabs 18 and 24 m and to bring them to a full factory readiness. It's appropriate to develop the assortment of considerably lightweight prestressed load-bearing frame structures for buildings with ultra-lightweight enclosure elements for roofs and walls made of iron sheet with a polystyrene foam core.

It is necessary to develop the assortment of lightweight composite structures (made of reinforced concrete and steel), including beams and columns with external reinforcement, roof slabs in the form of reinforced concrete prestressed frames and iron sheet membranes (with a synthetic insulant) fixed on these frames. Prestressing is expected to be widely used as means to joint beams and columns in frame frameworks of buildings. It is required to expand the use of tridimensional structures which make it possible to make efficient use of rentable area in industrial buildings due to enlargement of a column grid that can provide expressive architectural aspect of civil buildings.

It is expected to extensively use the buildings, developed with the collaboration of the bearing and enclosure structures, plates and beams of floor and roof slabs, wall protections and the framework, frame of the stiffening core. The task to enlarge wall panels can be solved by using lightweight concrete which reduce material and power consumption. For the production of lightweight concrete structures it is necessary to use claydite gravel with an average bulk density no more than 500 kg/m^3, launch manufacturing of haydite sand, to apply more widely expanded perlite sand as fine aggregate, to produce lightweight concrete with porous cement stone. For the cases when it is impossible to obtain the bulk weight of lightweight concrete lower than 1100 kg/m^3, enclosure structures have to be either three-layer or with heat-insulating inserts.

The fabrication yard of lightweight concrete has to develop on the basis of natural porous aggregates, and also aggregates produced on the basis of fuel-containing waste. Further development of porous gravel with an average bulk density more than 600 kg/m^3 is considered unreasonable.

Basing on the application of lightweight concrete and prestressed reinforcement there can be used single-layer panels up to 12 m long and up to 3,6 m high with windows for one-storey and multistoried buildings, two-layer panels with vertical bond as well as three-layer panels.

The main directions for the development of multistoried buildings are connected with the increase in number of storeys and sizes of column grids up to 9x12, 12x12 m. Besides, there will be developing the system of two-storeyed buildings with considerable loadings over the floor slab of the first floor. The improvement of multistoried building structures will be carried out towards the development and application of structures for multiservice multistoried buildings assembled with the elements of one assortment.

According to Central Scientific Research Institute for Experimental Housing Design, in 1981 – 1985, there was finished and introduced in housing construction of three-layer reinforced concrete panels with flexible ties. These structures ensure the decrease in fuel consumption for heating of the dwelling for 10 - 12% with simultaneous decrease in reduced costs for 10 rubles for 1m^2 of total area.

There were developed and introduced roof structures with a warm attic and non-roll reinforced roof slabs with a mastic waterproofing. The total number of housing development projects with the specified structure is 47. According to them there are being built 40 million sq.m of total area a year. Economic benefit made 1,7 million rubles, in case of economizing 1,6 thousand tons of bitum and 3,2 thousand tons of cond. fuel a year.

There have developed and introduced new structures with the use of lightweight concrete. Among them:

- single-layer panels of external walls made of lightweight porous no-sand concrete with the use of foam, providing at the average bulk density of claydite of 500 and 600 kg/m^3 the density of concrete of 900 and 1000 of kg/m^3. The structures ensure 45% of claydite saving and decrease in heat conductivity by 25 and 16% respectively;

- bearing and soundproofing panels of internal walls and floor slabs of large-panel housing made of structural claydite concrete base on heavy sand with the small concentration of porous aggregates ensuring claydite consumption in 0,22 m^3/sq.m of total area (more than twice as little than regular consumption of crushed stone);

- interflooring with a separate floor structure, non-split cantilevered balcony and floor slabs of a recess balcony reinforced by prestressed tubular registers of ceiling and panel radiant heating, providing decrease in heat for 20% and a consumption of steel by 2 times.

Combined application of lightweight concrete with the proposed structural solutions will make it possible to reduce labor input in materials production for 18% (for 5400 people/years.). The list of the innovative structural solutions applied in housing construction in 1981-1985 is provided in table 15.

In 1981-1985, there will be developed reinforced concrete roofing made of weather-resistant concrete and produced preproduction run for mass construction. The application of such structures will make it possible to abandon waterproofing roofing in garret roofs, thereby to lower labour input and to have economic benefit 1,5 rubles on 1 sq.m of the useful floor area. This direction is innovating for the mass housing construction.

In 1981-1985 and the next years it was supposed launch mass adoption of the structures made of lightweight concrete. Considerable resources of increase in labor productivity in the sphere of prefabricated housing construction also lie on the way of the use of industrial products of the increased factory readiness i.e. volume blocks.

Table 15

The list of the innovative engineering solutions applied in housing construction in 1981-1985

Engineering solution	Unit of measure	Savings for a unit of measure				Project series, with solutions (according to graph 1)
		Metal, kg	Cement, kg	Labour input, resource days	Energy source, kg.cond. fuel	
1	2	3	4	5	6	7
1. Foootings						
Reinforced concrete slabs for strip foundation with economizing reinforcement series 1.112-5, output 0-4	m^2 of total area	0,15	3,0	-	-	Catalog, all series
Non-grillage pile foundation	″	0,5	2,4	0,025	-	90,121,91, 141, 93, 83, 84
Pile foundation в in rammed down excavation pit	″	1,38	6,4	0,029	-	83, 90, 121
2. External walls						
One-layer lightweight external wall panels series1.132-1/82 and 1.132-2/82	m^2 of total area	0,5-1,5 0,12-0,4	-	-	-	Catalog, all series
Reinforced concrete bearing three-layer external wall panels with effective insulant and flexible ties series 1.132-3/82	″	0,5	10,0	-	10,0	84
Bearing three-layer panels made of claydite concrete with firm ties, insulant-rigid mineral wool slabs	″	0,5	10,0	-	10,0	84

1	2	3	4	5	6	7
3. Internal walls and partitions						
Internal walls panels made of heavy concrete according to 1.131-3/82	m^2 of total area	0,15	-	-	-	Catalog, all series
4. Floor slabs						
Multi-hollow floor slabs series 1.141-1, output 58, 59, 60, 61	″	0,5-1,7	-	-	-	Catalog 81, 85, 86
Floor solid slabs, 160 mm thick with the support in three sides	″	0,6	-	-	-	83, 84, 121,90-вар.
Multi-hollow floor slabs, produced by casting without forms on long benches	″	1,1	-	-	-	81, 85, 86, 141
Reinforced concrete lintelns for brick houses according to series1.138-10, output 1- 8	m^3	18,0-23,0	-	-	-	85, 86
Multi-hollow floor slabs	m^2 of total area	1,0				141,3-600
5. Others works						
Volume items of elevator shafts according to 1.189-6, output 3 (82)	1000 m^2 of total area	0,1	-	4,0	-	All series
Three-dimensional utility blocks according to 1.188-5	m^2 of total area	-	-	0,09	-	121, 93, Э-600
Industrial non-roll roofing in large-panel housing	″	-	-	0,033	-	90, 121, 141, 83, 84
Pressed embedded parts in reinforced concrete products	″	0,4	-	0,005	-	90, 121, 464Д

The application of volume elements in prefabricated buildings which weight lies within loading capacity of mass assembly cranes, will make it possible to raise labor productivity on the construction site up to 35% and 12% in the system plant-construction site. The increase in loading capacity of the crane equipment offers challenges to use volume blocks up to 15-18 tons and provides decrease in total labor input to 1,5-2 times. It was necessary to continue research and project works towards the decrease in material and power consumption of prefabricated reinforced concrete for large-panel housing.

In housing construction it is necessary to increase the use of enriched and fractioned nonmetallic materials to 110 million m^3 in 1985 to 150 million m^3 in 1990 that will make it possible to save up 800 thousand tons of cement, and about 160 thousand tons of cond.fuel. The application of plasticizers in 1990 when producing 50 million m^3 of prefabricated reinforced concrete for housing construction in comparison with 2 million m^3 in 1985 will give the chance to save about 3,4 million tons of cement, to gain annual economic benefit of 90-100 million rubles, to increase productivity of technological lines on average for 20% due to the reduction of thermal treatment cycle for 2 - 4 hours, to lower labour input approximately by 5-7% due to the reduction of vibration time.

It is appropriate to continue structure improvement of cement use according to concrete functional purpose according to its grades and classes, to spread the use of plain cement and special types of cement (rapid-hardening, self-stressing cement, sulfate-resisting cement, etc.). It will provide cement saving by 2-3% of the total amount of its application. It is necessary to keep using low-clinker and non-clinker cement, in particular, blast-furnace binders in amount of 1,5 million t a year that will make possible to save 1million tons of Portland cement.

It would be appropriate to keep using and increasing the amount of high-strength reinforcement steel of the following classes A-V, A-VI, At-V, At-VI, At-VII, wire V-2 and strands from 1355 thousand tons in 1985 to 1500 thousand tons in 1990 that will reduce up to 40 thousand tons of reinforcing steel.

3. THE DEVELOPMENT OF EFFECTIVE TECHNOLOGICAL PROCESSES AND HIGHLY MECHANIZED AND AUTOMATED MACHINERY

In 1981 – 1985, in production sector there were developed and introduced advanced technological processes, lines and machinery, including:

- new technological processes and machinery of automated storages for cement and aggregates which minimize material losses, increase productivity of receiving and withdrawing apparatus;

- technology of chemical additives application – superplasticizers (preparation, additives handling, preparation of concrete mixes, casting of products). It gives an opportunity to cut down cement consumption for 10-20%, to improve line productivity for 10-15%, to reduce labour input for casting by 2-3 times;

- automation equipment for preparation of concrete mixes (TSIKL-BS, SUBZ-2, UD-1 systems, etc.) make possible to improve the quality of mixes, to reduce cement consumption for 2-3%, to lower labour input for concrete mix preparation by 1,5-2 times;

- automated installations and lines for preparation, prestressing and placement of reinforcement which bring an opportunity to reduce metal losses by 10-20%, to raise labour productivity for 10-30%;

- effective greasings of metal casts on the basis of wax components give the chance to abandon cleaning flat horizontal casts, to receive high quality surface of products without additives and to gain economic benefit of 0,2 rubles for 1m^2 of products;

- new casting processes [2,8] on low-frequency vibroplatforms, roller installations, modernized concrete distributors which make it possible to lower labour input for casting by 1,5-2 times and, therefore, to improve working conditions;

• casting of products without forms on long benches using international practices makes it possible to lessen labour input by 1,5 times and to improve product quality;

- the processes and units for thermal treatment of products according to energy saving modes with automation which provide an opportunity to cut down energy consumption by 10-30%;

- effective methods of front finishing of buildings: architectural concrete, decorative components, a plasma coating, etc. make it possible to improve the quality and architectural aspect of prefabricated buildings;

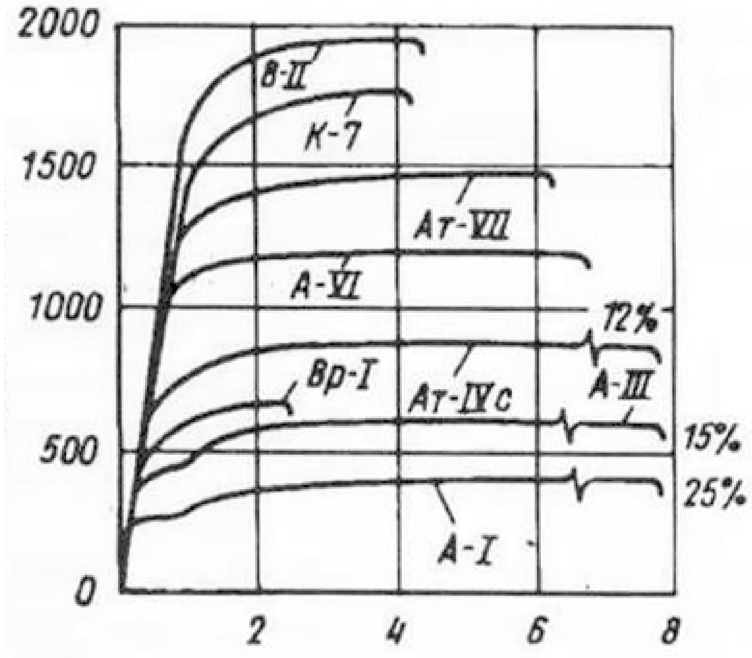
- methods of thermal treatment of products by means of natural gas and solar energy provide the decrease in energy consumption for 150 $Mcal/m^3$;

- effective conveyor and semi-conveyor lines for various products (two-stage, three-stage, inclined closed, biramos, etc.) enable to minimize specific capital investments and operational costs for 10-20%;

- battery-mould lines for the production of internal walls panels allow to reduce labor input by 20-30% and strongly to improve working conditions.

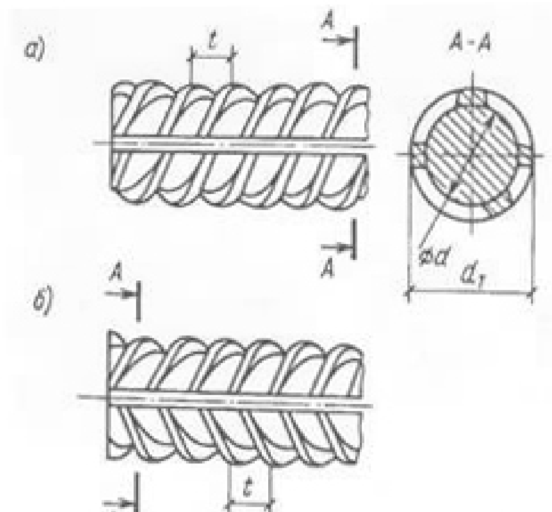
Deformation stress for different steel

Stress, MPa



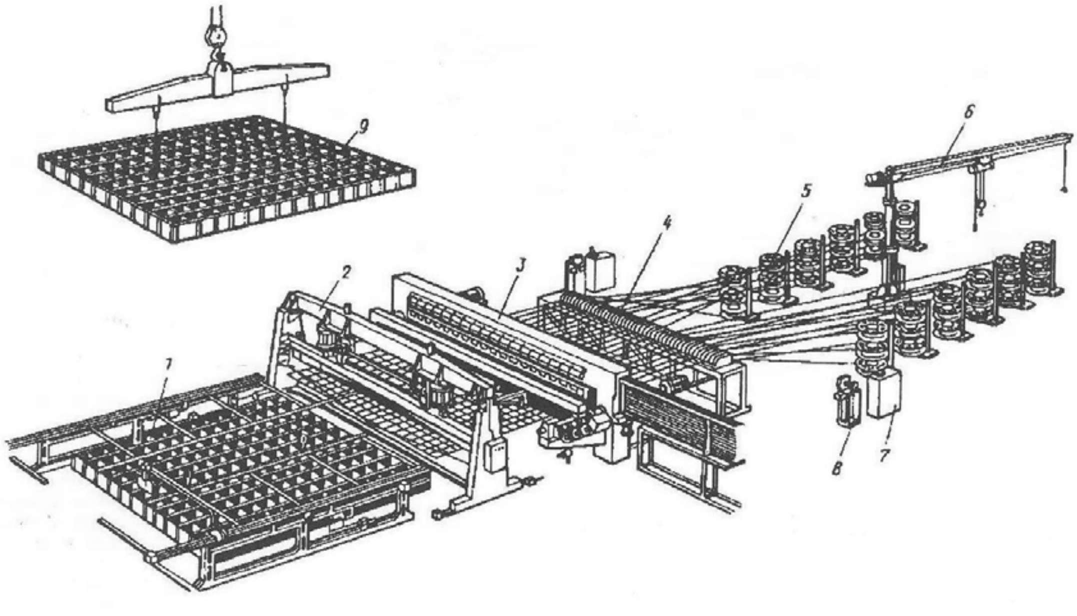
Percentage elongation, %

Cross-section of reinforcement bar

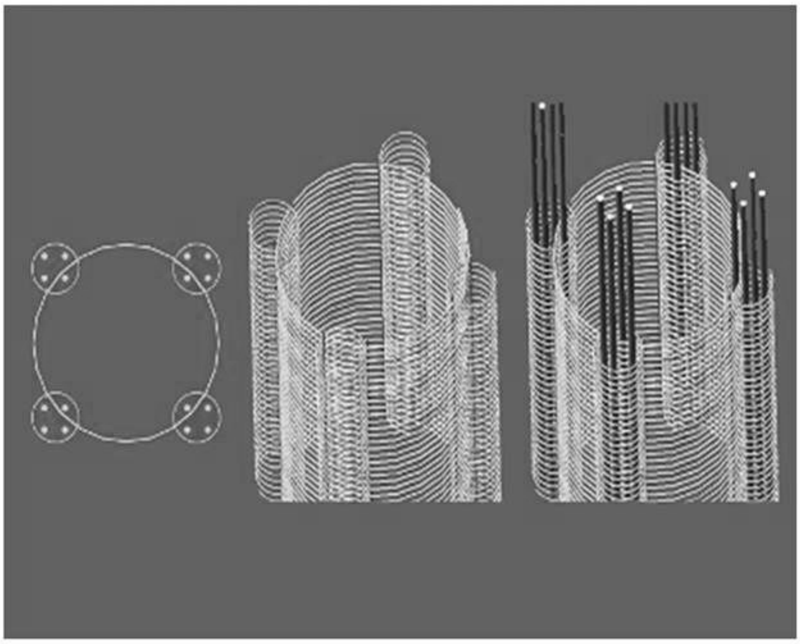


a) A-II class

b) A-III-At-VII classes

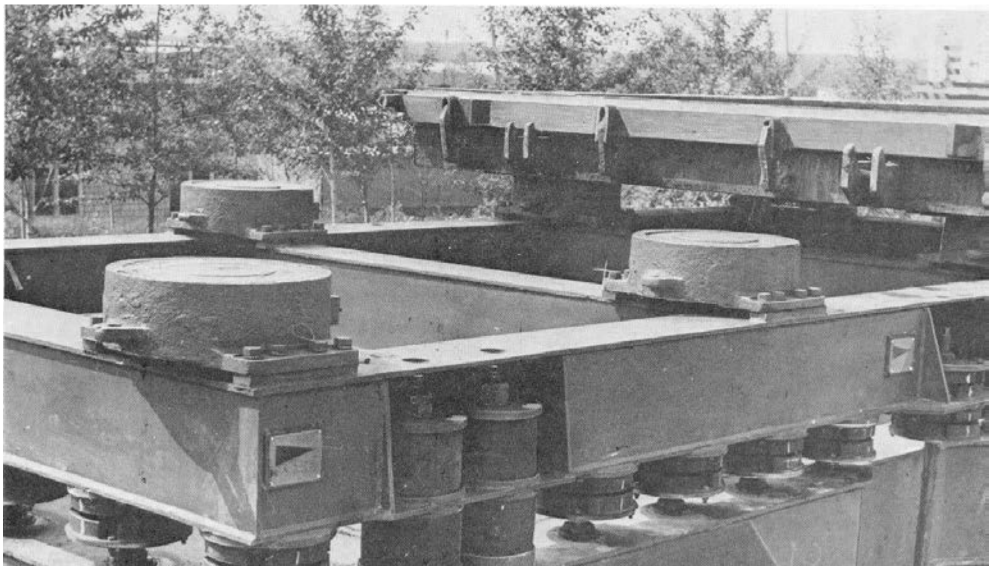


5. Automatized line for the production of flat mesh reinforcement:
1) piler; 2) scissors fort he cross cutting of reinforcement;
3) multi-electrode welding machine; 4) straightening device;
5) wire-reel stand; 6) cantilever crane; 7) machine for butt welding;
8) electric grinder for die trimming; 9) mesh bundle

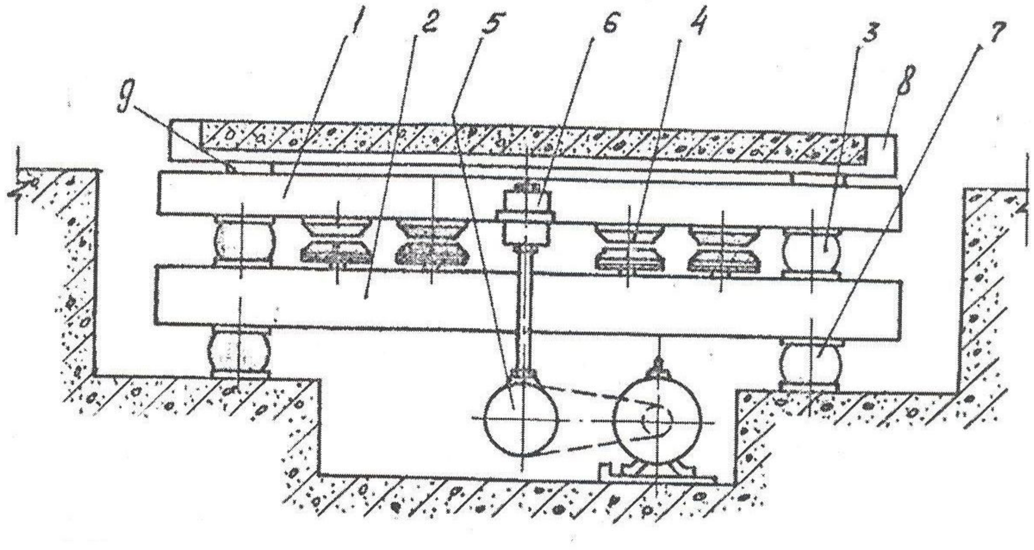


6. Spiral reinforcement of columns

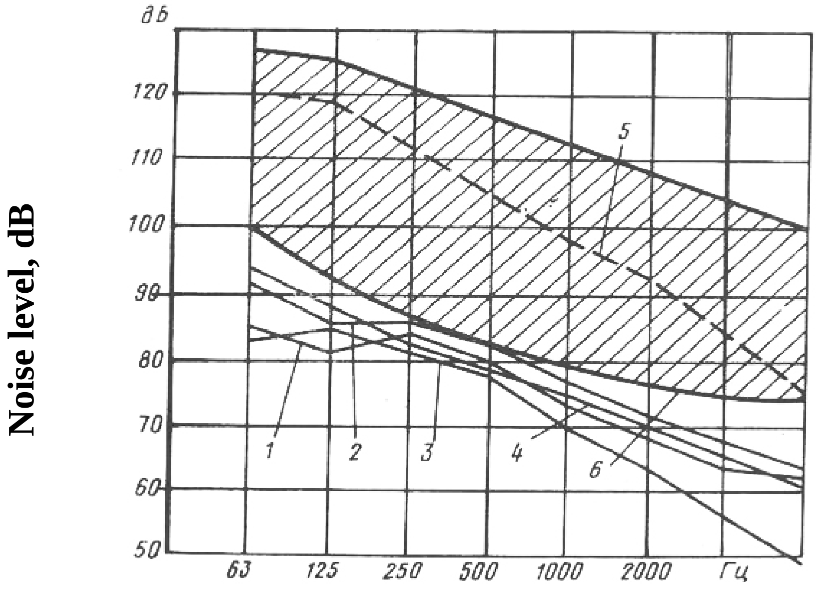
7. Automatized installation for coil winding



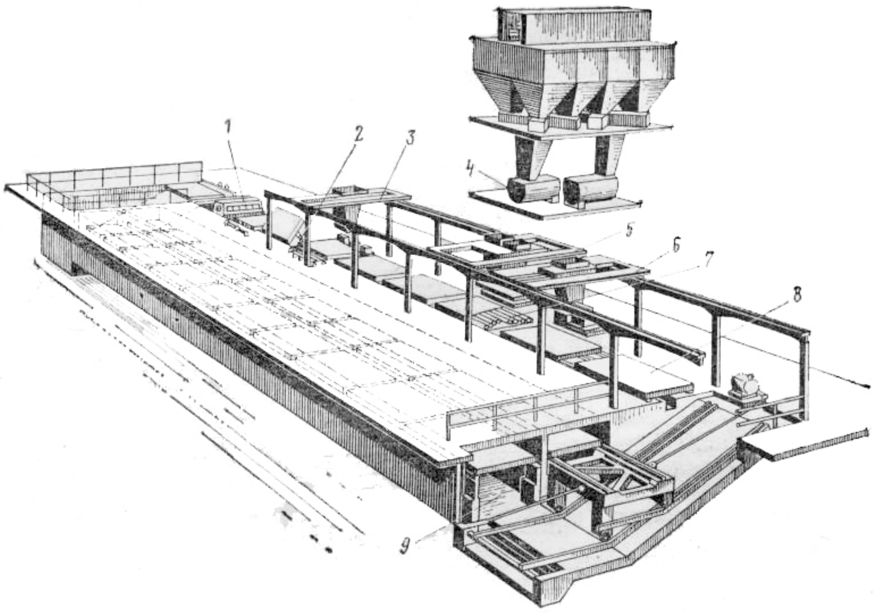
8. Low-frequency resonant vibrotable



9. Principal diagram of the asymmetric vibrotable of VRA type:
1 – driven element, 2 – balance frame, 3 – absorbers, 4 – buffers,
5 – eccentric drive, 6 – crank arm, 7 – absorbers, 8 – cast,
9 – electromagnets

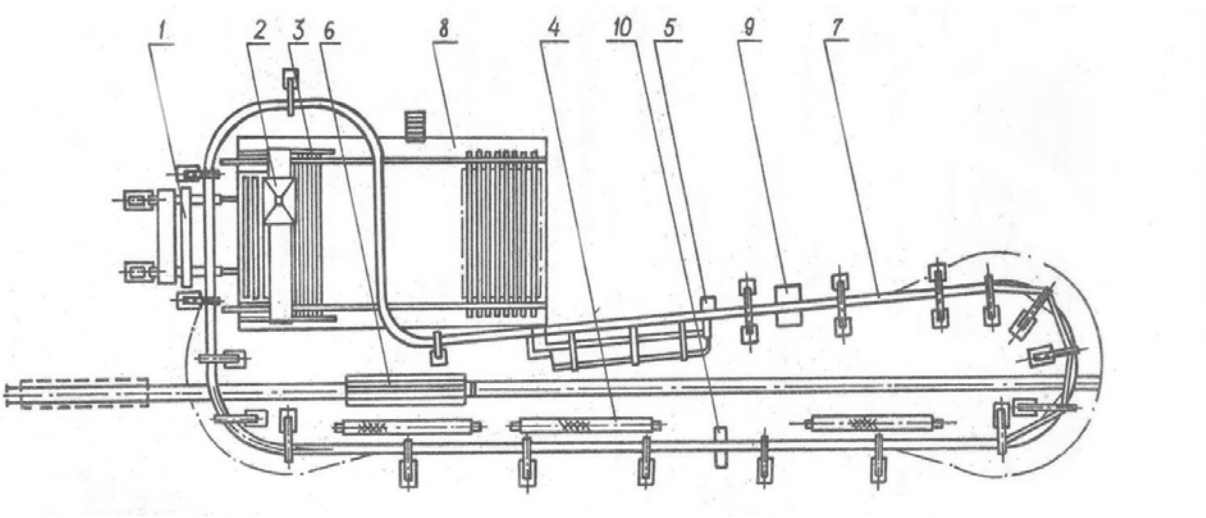


10. Spectral noise recording of different vibrotables
(dashed area is the noise range of serial tables)
1, 2, 3, 4 are different vibrotables with and without a load
5 is a stroke post; 6 is the limitary spectrum PS-80



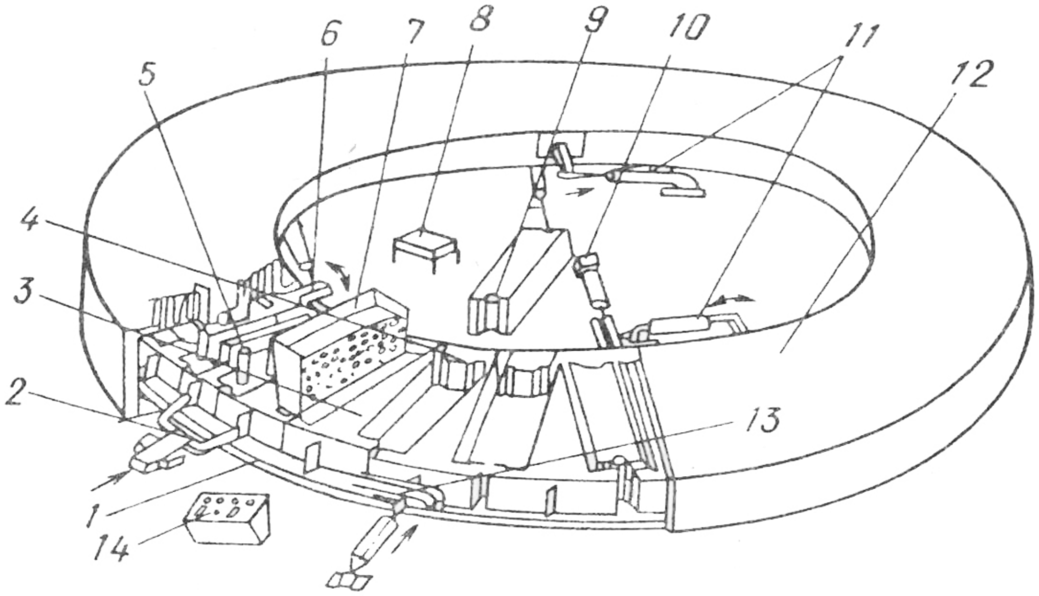
11. Scheme of inclining and locked conveyor in 1970-1980

1. Finishing machine;
2. Inverting unit
3. Mix placing machine for lower layers
4. Local automatc concrete mixer
5. Double-bunker concrete placing machine
6. Mix placing rubbing machine
7. Resonant vibroplatform
8. Bottom plate with an item
9. Slatted rooms for thermal treatment



12. Scheme of battery-mould line at Kamensk-Uralsk Integrated Home-Building Plant

1. Cassette
2. Beam of concrete placing device
3. Carriage for waste
4. Filling-in device
5. Dismantling carriage
6. Mechanized cleaning station
7. Hand cleaning station
8. Greasing station
9. Reinforcement cage station
10. Huddling carriage



13. Rotor and conveyor line

1- Circular revolving bottom plate
2- Fixation mechanism
3- Wedgebar casting
4- Mould edge
5- Vibration-rolled concrete
6- Mechanism for fixing hinges
7- Storage bin
8- Hydro-station
9- Mechanism for block unloading
10- Mechanism for dismantling
11- Lever drive, swing drive for bottom platform
12- Annular chamber for thermal treatment
13- Mechanism for mould assembling
14- Remote control

However, the level of adoption of the specified advanced developments in 1981-1985 was rather insignificant: 80-100 units of new sets and types of the equipment which together with the advanced technological processes cover no more than 10% of total output of prefabricated reinforced concrete.

In 1986 – 1990, it was necessary to increase implementation scope of advanced technologies and equipment. According to the estimates of the USSR State Committee for Construction and construction ministries, there had to be adopted: more than 1800 automated storages for cement and aggregates, about 1000 automated batching plants and departments, about 120 million m^3 of the products made with the use of effective chemical additives i.e. superplasticizers; more than 1500 automated installations and lines for reinforcing production, effective greasings for casts for the production of 45 million m^3 of products, about 3000 innovative casting units, more than 50 benches for casting without forms, more than 2800 effective curing rooms, including 1000 rooms with the use of natural gas, 5 million m^3 of reinforced concrete with solar thermal treatment, 50 lines of full factory finishing of external panels, 300 effective conveyor and semi-conveyor lines, more than 150 battery-mold lines.

In the 90s, there had to be created prototype models of more effective automated lines and equipment configurations for mass production of articles, hollow floor slabs, basement wall blocks, pavement slabs, grapevine trellis, external panels of strip bond, etc. which were expected to be widely used. In the 90s, it was necessary to develop and introduce new technological processes for high-performance conveyor and bench productions: vacuum vibrocompaction, impulse compaction, continuous non-vibration casting methods, hardening processes on the basis of rapid-hardening Portland cement and jet cement, containerization of end products.

In 1981-1985, there were developed and adopted innovative technological processes to improve thermal characteristics of single-layer lightweight concrete wall panels for industrial buildings which were considered to be one of mass types of reinforced concrete structures. The most economic and effective one is the joint use of such fine aggregate as the ash from Combined Heat Power Plant and porous air-entraining additive. Such technology allows to lower cement consumption by 10% and without the increase in power-intensive claydite to raise thermal characteristics of panels for 20% and even more. In 1985, according to such technology there were produced more than 600 thousand m^3 of articles. By 1990, the amount of their production made up 1,5 million m^3. Mass production of single-layer panels with the improved thermal characteristics avoids the necessity of transition to the production of multilayered panels the labor input of which is 10-15% higher, than single-layer ones.

In 1981-1985, in the field of special reinforced concrete there were developed innovative structures made of reinforced concrete and effective technological processes:

- the vibrohydrualic compressed pressure pipes with spiral two-way reinforcement with a diameter of 800-1200 mm. In the process of their production about 5-8% of reinforcement is saved and labor productivity is increased by 20-25%.

Until 1995, it was planned to mass-produce such pipes, to extend the diameter range up to 500-1600 mm and create pipes with a reinforced protective layer that will make it possible to improve their durability and to use in corrosion environment [1];

- centrifuge milling pressure pipes with a diameter of 1200-2000 mm which are considered to be functional structures allowing to use reinforced concrete pressure pipes in a wider range of diameters (in the 90s it is planned to work up these technological lines for the production of such pipes);

- radially compressed pressure pipes with a diameter of 300-600 mm, in the process of their production there can be saved on average 10-15% of reinforcement and raised labor productivity by 2,0-2,5 times. By 1990, it is planned to launch a pilot production of such pipes, and by 1995, to develop 10-15 lines for their fabrication of about 200 thousand m^3 a year;

- reinforced concrete pipes for container pneumatic conveyor systems allowing to save up to 200 tons of metal for 1 km of pipeline. In the 90s, it is planned to mass produce such pipes at the Gnivansky Prefabricated Reinforced Concrete Plant in the quantity of 30 km a year.

In 1981-1985, All-Union Scientific Research Institute for Concrete and Reinforced Concrete developed engineering proposals on the creation of fundamentally new high-performance manufacturing technology for reinforced concrete railway ties on the basis of innovative, more technological and effective structure based on the application of enlarged reinforced elements (reinforcement bars of high classes and wire strands with a continuous coiling on internal anchor). There will be also simplified the connection of rails to a railway tie which gives an opportunity to considerably reduce manual labour.

The activities in this direction were carried out according to two industry programs which, in 1990, will be completed by the development and introduction of a pilot production of new railway ties. The emerging technology differs from the standard one by the increased productivity not less than by 2,5 times and by the decrease in labor input for the production of railway ties by 1,5-2 times.

In 1981-1985, for housing construction there was developed and introduced at Gorky Large-Panel Housing Plant # 4 a production technology for floor slabs of residential buildings with an opposed arrangement of adjacent emptiness and two-way introduction of blockouts–core driver. Such design and engineering solution makes it possible to use slabs in high-rise buildings with platform joints without closing. In 1985, there were manufactured 10 thousand m^3 of such multi-hollow floor slabs.

There were developed structures and manufacturing techniques for two-layer panels of floor slabs and bottom for dwellings with a warm attic. The technology includes systematic casting of heavy and lightweight, structural and heat-insulating concrete, thermal treatment and the subsequent coating of products by bitumen mastic emulsion on solid emulsifiers. The technology ensures full factory readiness of products, gives a chance to reduce labor input in the process of construction and building operation, in comparison with the option of roll roofing. Thus, the reduced costs decrease for 0,5 rub./sq.m of total area, and labor input for 0,2 man-hour/sq.m total area. The production of such panels is launched at Gorky Large-Panel Housing Plant # 4 for construction houses of E-600 series.

There was developed (Central Scientific Research Institute for Experimental Housing Design) and introduced at Gorky Large-Panel Housing Plant # 4 the production technology of external wall panels with flexible ties. In the same place there was adopted the technology of concrete electric heating for the production of internal and external walls. The use of electric heating allows to reduce heat carrier cost for warming up1m^3 of products for 2-2,5 rub. or by 1,75-2 times.

In Central Scientific Research Institute for Experimental Housing Design, Scientific Research Institute for Concrete and Reinforced Concrete, Technology Design Bureau of Head Department of Constructions Materials and Details Industry of Moscow City Executive Committee there was developed the technology of casting three-dimentional utility block, small volume blocks and other house-building items with the use of shock and vibration method of compacting concrete mixes. This method involves joint impact of vibration with the frequency of 2800-6000 osc./min and with the amplitude of 0,05-0,12 mm.

Shock and vibration casting makes it possible to produce thin-wall structures of a difficult configuration and with high density of reinforcement with the use of low-workability concrete mixes instead of flow concrete mixes at traditional battery-mould technology. It allows to cut down on cement consumption for 20-25%, and prime cost of products - for 2-2,5 rub./m^3.

For the 90s there was planned the following development of the listed below technological processes:

- development of technology for factory production of three-layer panels with flexible ties assembled from separately cast layers;

- production technologies of external wall panels with monolithic cast thermal insulation;

- technology of shock and vibration casting of small volume blocks with sizes 3x3 and 3x6 m;

- production technology for hollow roofing panels made of weather-resistant concrete.

The most important resource of decrease in labor input lies in the intensification of technological processes, in particular, of heat treatment. In 1985, the technology of heating mixes with steam was adopted by Rostokinsky plant of Reinforced Concrete Structures, Integrated Home-Building Factory #1 (35269 sq.m output, economic effect 100164 rubles). In 1986, it is planned to produce 110 thousand sq.m of articles.

The intensification on the basis of the integrated use of preheated concrete mixes, plastic forms of a small metal consumption and chemical additives developed in Scientific Research Institute for Concrete and Reinforced Concrete, Central Scientific Research Institute for Experimental Housing Design in 1986-1990 will provide energy saving up to 3 times.

Further intensification is possible only on the basis of jointed mechanization and automation, including robotization. Table 16 presents data on robotic tools/facilities, implemented at the enterprises of construction engineering sector in 1981-1985.

When constructing large-panel housing at the suggestion of Central Scientific Research Institute for Experimental Housing Design there was made the list of processes and operations where the use of robotic tools at current technology will make it possible to reduce labor input in factory production by 15 man-hour/sq.m of the total area, i.e. on average for 25% in the sector:

- opening, closing of boards, locks of casts; installation of concrete inserts; installation of three-dimentional frames; laying of heat-insulating material; laying of a claydite tile; laying of a large-size tile; installation of the joiner's block; assembly of the battery; cut of the ends of prestressed reinforcement; heating of rods and placement of prestressed reinforcement;

Table 16

The list of the implemented robotic facilities

Enterprise	Grade, economic benefit	Operation type
1	2	3
Vyazemsky Plant for Reinforced Concrete Items of the USSR Minstroymaterial	-	Turning and milling machines service
Glavdorstroy of the USSR Ministry of Transport Construction	PAI1-300 3 thousand rubles	Border stone laying
Vladivostok Reinforced Concrete Plant of Ministry of Construction for the Eastern Regions of the USSR	KMYUC 4202 7,5 thousand rubles	presswork of concrete inserts
Blagoveschensk Integrated Home-Building Factory of Ministry of Construction for the Eastern Regions of the USSR	KMYUC 4202 3,0 thousand rubles	presswork of concrete inserts
Khabarovsk Integrated Home-Building Factory of Ministry of Construction for the Eastern Regions of the USSR	KMYUC 4202 7,5 thousand rubles	presswork of concrete inserts
Woodworking Integrated Plant # I Khabarovsk Ministry of Construction for the Eastern Regions of the USSR	SHBM-150 4,5 thousand rubles	Hanging and removing of millwork
USSR Krasnopresnensky Integrated Home-Building Factory # 1	SHBM -150	Auxiliary operations in Maintenance and Repair workshop
USSR Krasnopresnensky Integrated Home-Building Factory # 1	SHBM -160	Fitting of wire bundles
USSR Lipetsk Branch of Experimental Design Bureau Lipetsk Ministry of Industrial engineering	SHBM -150	Production of concrete inserts

Experimental Design Bureau Ministry of Industrial Engineering USSR, Tula	SHBM -150	Removal of door panels
	KM-0,6C4212	Items fixing on press

- service of SMZh-357; SZ70A; SMZh-173a; MTM-33; 7251A; SMZh-128a; SMZh-286; SMZh-54A;
- discharging of cement sacks; unpacking of cement sacks, strengthening of decorative tile coverings; cutting of the heat-insulating material; storage of finished goods; placement of section matrixes; coloring by silicon - organic enamels; addition of shattered material.

4. THE USE OF NEW TECHNOLOGICAL LINES, EQUIPMENT AND TOOLING IN 1986 – 1990

In 1981-1985 according to special-purpose programs and comprehensive programs there were developed, tested in prototypes and planned for serial production of new systems of machines and equipment for flow-lines to mass-produce reinforced concrete articles which hadn't been manufactured earlier, or for more modern technological processes.

State Design Institute for Building Machine Manufacturing developed, conformed to primary consumers, and approved 35 systems of machines and equipment for the production of various reinforced concrete articles which had to be produced by the Ministry of Building and Road-Making Machine-Building Industry in 1986-1996. These systems include 13 systems for residential construction and civil engineering, among them:

- machines and equipment for horizontal flow-line production of single-layer external wall panels 7, 2×3,1 m with thermal treatment in underground or track sections rooms for large-panel housing plants with the capacity of 140 and 180 thousand sq.m of total area per year;
- machines and equipment for horizontal production of three-layer external wall panels for large-panel housing plants with the capacity of 140 thousand sq.m of total area per year;
- machines and equipment for horizontal production of floor slabs and internal walls for large-panel housing plants with the capacity of 240 and 180 thousand sq.m of total area per year;
- machines and equipment for vertical production of floor slabs and internal wall panels for large-panel housing plants with the capacity of 140 thousand sq.m of total area per year;
- machines and equipment for vertical production of internal wall panels in battery-mould installations for large-panel housing plants with the capacity of 140 thousand sq.m of total area per year;

- machines and equipment for production of volume elements according to batch technology, for large-panel housing plants with the capacity of 180 thousand sq.m of total area per year;

- machines and equipment for horizontal production of non-standard precast articles for large-panel housing plants with the capacity of 140 and 180 thousand sq.m of total area per year;

- machines and equipment for the production of multi-hollow floor slab panels 1,2x6,3; 1,5x6,3 and 3x7,2 m for residential construction and civil engineering. State Design Institute for Building Machine Manufacturing developed and approved standard projects of flow-lines for all abovementioned machines and equipment.

Taking into account the fact that in 1981-1985 the equipment of specified systems will be widely applied in construction, reconstruction and technocal retooling or reequipment of operating enterprises of large-panel housing. The USSR Ministry of Transport Construction created capacities on increase in its production . Whereas it is necessary to reduce manual labour input at the construction site and, therefore, to increase factory readiness of large-panel housing products, much attention has to be paid to the development of new equipment and to its expansion.

In 1984, there were completed acceptance trials and approved a new five-station SMZh-463-468 flow-line for finishing and a complete set of external wall panels. Mass production of these panels sets in at Lysychansk Strommashina Plant. There was carried out the modernization of serial equipment which is produced by Kokhomsky Plant "Strommashina" for finishing internal wall panels and floor slab panels.

In 1985, there was launched mass production of SMZh-461 machines for finishing as-formed surfaces panels. This machine will be manufactured by the type of a well-proven machine operating at Head Department of Construction Materials and Products Industry of Leningrad City Council of Reinforced Concrete Plant No. 21. The technological level of this equipment completely meets modern requirements.

For industrial and water management construction there were developed:

- machines and equipment for flow-line production of external wall panels 3,0x6,0 m for industrial construction;

- machines and equipment for flow-line production of prefabricated reinforced concrete structures for industrial construction with a forming stations of 3x6 m;

- machines and equipment for the production of reinforced concrete walls and roof slabs for industrial buildings o 1,5x12 and 3,0x12 m in size;

- machines and equipment for the production of complex plates for roof slabs 3x12 m in size for industrial buildings;

- machines and the equipment for the production of roof slabs of "P" and "KZhS" types 3x18 m in size for industrial buildings;

- systems of machines and equipment for the production of reinforced concrete pressure vibrohydraulic compressed pipes with the diameter of 500-1200 mm and 1400-1600 mm of traditional reinforcement;

- machines and equipment for the production of reinforced concrete pressure vibrohydraulic compressed pipes with the diameter of 800-1200 mm with spiral two-way reinforcement;

- machines and equipment for the production of reinforced concrete pressure pipes with the diameter of 300-600 mm with a metal cylinder;

- machines and equipment for the production of concrete and reinforced concrete non-pressure pipes with the diameter of 300-600 and 800-1200 mm;

- machines and equipment for the production of reinforced concrete racks of pylon for illumination pole and overhead contact systems and all-electric passenger transportation by the centrifuge method;

- machines and equipment for the production of reinforced concrete pylon of grapevine trellis by the method of roller pressing;

- machines and equipment for the production of reinforced concrete railway ties;

- machines and equipment for the production of road and airfield slabs made of fine-grained concrete by the method of roller compacting.

There was carried out the modernization of all machines for straightening, cutting and bending of reinforcing steel. After the trial of high-performance multi-electrode welding machine MTM-88 conducted by the USSR Ministry of Electric Power Industry, Bologovsky Strommashina Plant crossed over to the production of new flow-lines with this machine. There were developed the ystems of machines and equipment for the production of wire-mesh reinforcement up to 775, 1450 and 3800 mm wide.

For fast introduction of machines and equipment systems developed by State Design Institute for Building Machine Manufacturing, the institute designed and sent to Kiev Branch of the Institute of Standard Projects the plans of horizontal conveyor lines for the production of external wall panels for large-panel housing plants of large and average capacity, floor slabs for the plants of large and average capacity. All these plans can be used both for the construction of new large-panel housing plants, and for reconstruction, expansion and technical reequipment of operating plants.

Experience has shown that the management structure at which planning and design organization along with the equipment development works out the standard projects of technological lines, shops, enterprises where this equipment is applied, allows with the shortest possible period of time to construct a project and to put it into operation.

In 1985, State Design Institute for Building Machine Manufacturing developed, coordinated with all construction ministries and leading research establishments and development organizations "General coordination plan of creation of new, improvement of operating and discontinuation of the outdated equipment for the production of prefabricated reinforced concrete structures and articles for 1986-1990." In this general coordination plan in 1986-1988 there was made a provision for research activity on the creation of new perspective technological processes and issue of requirements baseline for the development of machine and equipment complexes in 1990-1995.

For the 90s it was planned to develop and to master mass production of new machine and equipment complexes:

- standard projects of cement storages of block and modular type of various capacity;

- concrete mixing floor with the productivity of 60 and 120 m^3 an hour;

- departments for storage, preparation and handling of chemical additives and superplasticizers;

- silo storage of aggregates of block type;

- two experimental plants with flexible system of panel housing construction;

- technological line on casting multi-hollow plates without moulds (on long benches 1,5 m wide);

- battery-mould line for vertical casting of slabby products;

- automated lines for the production of wire-mesh reinforcement with new welding machines - 5 names;

- robot modules for the production of pressed and welded embedded details;

- production of dry mixes on the basis of cement and plaster binders and the tool for their insertion;

- prefabricated large-panel housing plant of houses of “Mobile” system;

- equipment for finishing of external wall panels with multi-color ceramic glaze;

- three-dimensional and block housing construction and small volume/ three-dimensional blocks, used in large-panel housing;

- technological line for roof slabs, roofs of residential buildings with a warm attic.

In 1987-1989, there were updated functional standard projects of technological lines to increase the production technology of large-panel housing. For 1990 there were accepted the following directions in technology development:

- automated and robotized technological lines on the basis of microprocessor means for horizontal casting of slabby products;

- flexible automated cells, sites and technological lines for reinforcing productions, casting floors, storages for end products, batching and other auxiliary departments;

- systems and complexes of automated management of the processes (Automatic process control system);

- development and introduction of automated design systems (SAD).

The production of the capital equipment and moulds was carried out by a number of the ministries and departments:

- the USSR Ministry of Building and Road-Making Machine-Building Industry –regular casting, batching, transport and reinforcing equipment; mould pallets for mass application; export supplies of equipment, moulds and facilities;

- the USSR Ministry of Electric-Power Energy - special welding machines and equipment;

- the USSR Ministry of Erection and Special Construction Works – battery-moulds installations and facilities for them; Ministries and departments - consumers (Ministry of Construction, Architecture and Housing of the USSR, the USSR Ministry of Industrial Engineering, the USSR Ministry of Heavy Engineering, the Ministry of Energy, etc.) – certain types of the equipment for in-plant use, moulds and facilities.

Taking into account the achieved overall production of reinforced concrete structures and current manufacturing process, about 60% of the general metal consumption goes for moulds and facilities to them. According to Central Statistical Administration the actual production of the equipment, moulds and facilities makes up about 260 thousand tons, of them the enterprises of USSR Ministry of Building and Road-Making Machine-Building Industry produced 110 – 120 thousand tons in 1985.

By 1985, USSR Ministry of Building and Road-Making Machine-Building Industry manufactured about 300 equipment items for the production of reinforced concrete articles for large-panel housing, industrial, agricultural and water management construction, pipes, railway ties, transmission towers, etc. The increase in equipment production is possible only in case of accurate specialization of plants of USSR Ministry of Building and Road-Making Machine-Building Industry and plants of the consumer- ministries, to satisfy the need of the enterprises in equipment for flow-lines of horizontal production of panel structures, battery-mold lines, for the production of three-dimensional elements for large-panel housing construction, flow-lines for finishing of external and internal wall panels and floor slabs, and other equipment demanding highly skilled machine-building production.

To transform the enterprises of prefabricated reinforced concrete for intensive development pattern, it is necessary to speed up equipment and moulds replacement at the operating enterprises.

The main requirements of consumers to machine builders are:

- development and introduction of innovative equipment and technology considerably increasing production efficiency;

- improvement of quality, durability and maintainability of the delivered equipment.

By 1986, the USSR Ministry of Building and Road-Making Machine-Building Industry was faced with the main objectives following from the main directions of economic and social development for 1986-1990 and the direction on a fuller satisfaction of the served branches including:

1. Systematic and planned improvement of the manufactured equipment in order to develop and master such number of machines and equipment as may be required.

2. Development and assimilation of serial production of robotized machine systems and complexes will be the most perspective direction of increase in labor productivity in the served branches.

3. Increase in machines and equipment standartization, improvement of quality and reliability, the use of automatic systems on the basis of microprocessor equipment.

4. Intensification of work on the decrease in all types of material and energy resources consumption, first of all, rolled steel.

The USSR Ministry of Building and Road-Making Machine-Building Industry developed standards of equipment metal consumption, moulds and facilities for $1m^3$ of prefabricated reinforced concrete structures and articles (table 17).

Table 17

Average standards of equipment, moulds and facilities demands for the production of prefabricated reinforced concrete (kg/m^3)

Years	Total	Standards, including	
		equipment	moulds
Until 1990	25,2	11,3	13,9
1995	23,9	10,7	13,2

Note. The average term of updating (replacement) of the equipment is taken 8,5 years, moulds and facilities - 4,2 years.

In estimations of the standards there were taken into account both equipment and moulds which according to Central Statistical Administration are included into "Equipment for Reinforced Concrete" and equipment of other mechanical engineering sectors, applied on a large scale in the prefabricated reinforced concrete production (batching equipment, machines for bending, straightening and are cutting, etc.).

The demand and estimates of the equipment for prefabricated reinforced concrete for the period until 1990 according to State Design Institute for Building Machine Manufacturing data are given in table 18. The average annual need for components and materials for the equipment production in prefabricated concrete industry is presented in table 19.

Table 18

The need and production of the equipment for in prefabricated concrete

	Unit of measure	1985	1990	Estimates for 1995
Total need	Thousand tons	655	783	783
Production (total), including	″	373	478	638
USSR Ministry of Building and Road-Making Machine Building Industry	″	118	178*	238
At the plant of the ministries and consumer-departments (according to USSR State Committee for Construction)	″	255	300	400

* Under the resolution of the Central Committee of CPSU and Council of Ministers of the USSR on15.08.1985 #776-160, including batching , storage and reinforcing equipment – 18 thousand tons

Table19

Requirements to the machine-building ministries
in terms of the creation and deliveries of accessories and materials
for the increase in productivity, increase in the amount of machines and
equipment for prefabricated reinforced concrete industry

Description of an article, material, specification summary	Ministry	Application	Approximate demand for a year
1. Automatic weigh batcher on strain meter * in structure: aggregate batcher, including three-dimensional ones for lightweight aggregates, batcher for cement and liquids and special additives with computer-assisted control systems	USSR Ministry of Electrical and Tool Engineering	Automated batching plants with the mixers 750 and 1500 l	600 sets

2. A special elevator with wear-resisting chains with productivity up to 400 t/h aggregate with the fineness to 40 mm with source point	USSR Ministry of Heavy Engineering Construction	Automated batching plants of different capacity	600 pieces
3. A conveyor belt with cross members for belt-type conveyor 800, 1000, 1200 mm width	USSR Ministry of Petrochemical Industry	Automated batching plants with the mixers 1500 l	100 000 lin.m
4. A high-strength rubber belt on caproic basis 1000 and 2000 mm width and 10-12 mm thick	USSR Ministry of Petrochemical Industry	Concrete distributors for moulding	1000 mm width - 5000 lin m 2000 mm – 4000 width lin.m
5. Vibration-proof roller bearings for vibroplatforms 3000 osc./min.	USSR Ministry of Motor Industry	Vibroplatforms with a loading capacity from 10 to 24 tons	
6. Sets of the modular equipment with DN=6mm; Consumption 12l/min; pressure 32MPa; DN=10 mm; Consumption 40l/min; pressure 20MPa	USSR Ministry of Machine-Tool and Toolmaking Industry	Hydraulic jacks	1000 sets
7. The motor reducers with the built-in brake with the power of 2-5kW	USSR Ministry of Machine-Tool and Toolmaking Industry	Accessory drive of moving	2000 pieces
8. The regulating and distributive hydroequipment with sleeves of a high pressure	USSR Ministry of Machine-Tool and Toolmaking Industry	Tube-forming mills	2000 pieces
9. Hydraulic oil motor wheels (in accordance with GOST 13531-74) with a loading capacity of 50 кТ, D 300mm, 6 … 30 rp/min	USSR Ministry of Machine-Tool and Toolmaking Industry	Accessory drive of moving	2500 pieces
10. Adjustable drive engineering package ET-3	USSR Ministry of	Accessory drive of self-propelled	1500 pieces

with a frequency of rotation of 10 … 1000 rpm, 5 kW	Electrical Engineering Industry	machine	
11. Electric drums for belt-type conveyors for belt width of 800,1000, 1200 mm	USSR Ministry of Electrical Engineering Industry	Belt-type conveyors	2000 pieces
12. Electric motors of series 4a 3000 rp/min of various power in the protected execution	USSR Ministry of Electrical Engineering Industry	Vibroplatforms	3500 pieces
13. Metal rolling "rectangular pipe" with the sizes of 300x200x6, 270x190x6, 300x200x6, 270x190x6, 240x180x5, 160x130x4 mm	USSR Ministry of Iron and Steel Industry	Metalwork of floor, stationary equipment and self-propelled machines	Minimum 10 thousand rubles for USSR Ministry of Building and Road-Making Machine-Building Industry
14. Bent profiles "channel" angle bar (from 40x40 to 270x100 mm sheet 3 thickness... 6 mm)	USSR Ministry of Iron and Steel Industry	Metalwork of floor, stationary equipment and self-propelled machines	Minimum 10 thousand rubles for USSR Ministry of Building and Road-Making Machine-Building Industry
15. Welding machines and equipment MTM-I60, MTM-88, MTM-I66, MTM-35. MTM-207, MTM-103, PDF-502, K-724A, ADF-200-I (modern) MTP-1110 with pincers, MPP-1111 KTP-8-6 (KTP-8-7) with pincers, KTG-8-2 (custom order)	USSR Ministry of Electrical Engineering Industry	Equipment systems and complexes for reinforcing works	Demand in pieces 150, 10, 60,100, 100,10 400,100, 100, 1700, 200, 200, -

* There had to be delivered modifications with mixers for 750 и 1500 l

5. TECHNICAL REEQUIPMENT OF PREFABRICATED REINFORCED CONCRETE INDUSTRY AND CAPITAL INVESTMENTS FOR THE 90S

The investment policy, improvement of reproduction and technological structure of capital investments has considerable impact on the acceleration of technical progress and increase in labor productivity in prefabricated reinforced concrete industry.

To solve a problem of considerabele increase in labor productivity - by 2,2-2,5 times, in the 90s it is necessary to riase intensification on a basis:

- speed-up of production equipment updating, first of all, due to a quick replacement of ineffective equipment with advanced and high efficiency one;
- innovative changes in the structure and management of production;
- increase in labour, technological and state discipline;
- improvement of business calculations, enhancement of the role of economic instruments and incentives;
- essential improvement of prefabricated reinforced concrete quality;
- improvement of working and living conditions, i.e. increase of socio-economic level in the sector.

The main economic and social development directions in the USSR was to concentrate all types of resources "first of all on modernization and reconstruction of the operating enterprises and on the construction of the objects defining scientific and technical progress and the solution of social issues". " In the 90s decision-making bodies set the challenge to update the active part of production equipment not less than by 2 times in comparison with 1981-1985 to increase elimination of outdated production equipment".

Considering the fact that nowadays the prefabricated reinforced concrete industry has 13 billion rubles of the main production equipment, of these 30% or 4 billion rubles are considered to be an active part (i.e. machines and equipment), including obsolete ones and those with low technological level, just for updating of active parts of production equipment will be required 7-8 billion rubles (taking into account sharp increase in equipment cost due to the introduction of new depreciation guidelines, automation, computerization, robotization, increase in social efficiency of the new equipment and the need to increase active funds for the general structure of funds, at least up to 45-50%).

Passive production equipment and even rather deteriorated one make about 8 billion rubles. When carrying out technical retooling it was necessary to fully update, at least 50% of passive equipment. It took 3-4 billion rubles taking into account the increase in price for materials. Besides, according to expert evaluation, it was required about 2-3 billion rubles for social programs and environmental protection measures. Therefore, the total amount of capital investments only for updating of production equipment taking into account ecological and social factors had to make 14-15 billion rubles for the period till 2000.

Besides, having the capacities of more than 160 million m^3 and coefficient of their use up to 0,92-0,93, in order to satisfy the demand in prefabricated reinforced concrete in amount up to 162 million m^3 there will be required to additionally introduce 14-15 million m^3 of new capacities.

According to the evaluations of Concrete and Reinforced Concrete Research Institute and All-Union Concrete and Reinforced Concrete Research Institute, capital/output ratio of prefabricated concrete production averages 96 rub./m^3. New capacities are supposed to be introduced mainly in Siberia and Far East regions. Taking into account the increase in the cost of the main production equipment, adverse climatic conditions, local conditions, and also related capital expenditures, for the development of local capacities, development of machine-building, power and raw bases, water supply, compensation of the losses caused by construction, environmental protection, construction of facilities for social and cultural life, transfer of workers and their families, training of builders and operators, transport construction, and also the expenses necessary for delivery of raw materials and export of finished goods, for providing passenger traffics, other neglected expenses and taking into account probable investment process, specific capital investments will average 200-

250 rub/m^3. Thus, for expansion of production there had to be additionally required 3-4 billion.

In total, for increase in production of prefabricated reinforced concrete up to 161-162 million m^3 with simultaneous technical updating of the industry and essential increase in labor productivity there will be required 17-18 billion rubles of capital expenditures till 2000 or 5-6 billion in 1986 - 1990. A considerable part of funds (65-75%) has to be covered by the funds for production development of prefabricated reinforced concrete industry and bank credits. It is necessary to start to produce and deliver reinforced concrete products and structures of high construction readiness, to increase the quality of prefabricated reinforced concrete which is connected with the increase in labor input for the production as well as to save natural resources and at the same time to use coproducts and returns [3].

Taking into account capital/output ratio of prefabricated reinforced concrete industry, it is necessary to use, first of all, as much as possible organizational and technical and socio-economic factors to increase production efficiency and growth in labor productivity, decrease in material consumption, safety of products when transporting, storing and installation, and also most effectively to use the centralized and not centralized capital investments, funds for production development of the enterprises producing prefabricated reinforced concrete, bank credits.

Table 20 presents analysis data of prefabricated reinforced concrete development for 1986-1990 developed by the Design Institute-2 on the basis of Concrete and Reinforced Concrete Research Institute and All-Union Concrete and Reinforced Concrete Research Institute and leading construction ministries producing 50% of prefabricated reinforced concrete across the country - the USSR Ministry of Heavy Engineering, the USSR Ministry of Industrial Engineering (ministries till 13.09.1986).

Of the total amount of the planned centralized capital investments in the sum of 2210 million rubles for reequipment and reconstruction by these ministries, except the Ministry of Construction, Architecture and Housing of the USSR, there was provided only from 22 to 26% of the centralized capital investments, and the main part of funds was again provided for the extensive proliferation of production equipment due to new construction and expansion of production. Thus, in the calculation of centralized capital expenditures there were not taken into account related expenses including all social and ecological factors. Non-centralized sources aren't taken into account either. According to the given data, for the expansion of production of prefabricated reinforced concrete in the 90s there will be required about 4,5 billion rubles of capital expenditures. The investment of such huge capitals in the industry of prefabricated reinforced concrete isn't connected with technical retooling and reconstruction plans at the enterprises of the sector, as well as with all-union and industry scientific and technical programs and, consequently, doesn't give an idea of growth in labor productivity and increase in production efficiency.

Table 20

Capital investments for the development of prefabricated reinforced concrete for 1986-1990 (according to the data of Concrete and Reinforced Concrete Research Institute and All-Union Concrete and Reinforced Concrete Research Institute, Design Institute-2 construction ministries and departments)

Ministry or Department	Total capital investment, million rubles	Technical reequipment, Million rubles	Reconstruction, million rubles	Overall technical reequipment and reconstruction		Extensionmillion rubles	New construction million rubles	Total: extension and new construction	
				Million rubles	Total %			Million rubles	Total %
USSR Ministry of Heavy Engineering	474,3	27,0	75,0	102	21,5	78,4	294,4	372,8	76,5
USSR Ministry of Industrial engineering	330,1	36,3	49,2	85,5	25,9	119,5	125,1	244,6	74,1
USSR Ministry of Construction	239,7	108,3	63,5	171,8	71,7	32,9	35,0	67,9	28,3
USSR Ministry of Construction for the Eastern Regions	406,1	44,2	49,5	93,7	28,1	110,6	201,8	312,4	76,9
USSR Ministry of Energy	353,6	39,9	44,9	84,8	24*,0	87,a	181,4	268,7	76;0
USSR Ministry of Water Administration	405,9	67,8	29,6	97,4	24,0	30,4	278,1	308,5	76,0
Total:	2210,2	323,5	311,7	635,2	28,7	459,1	1115,8	1574,9	71,8

It is also necessary to take into account that according to the State Planning Committee of the USSR, Research Institute for Power-Producing Constructions, of the State Committee for Construction of the USSR, the amount of capital investments in the industry of prefabricated reinforced concrete for 1981-1985 made 3,44 billion rubles. The gain in production during this time increased by 13,0 million m^3.

In case of specific capital investments of 108 rub/m^3 (data of Research Institute for Power-Producing Constructions) for the specified gain in production there were spent 1,4 billion rubles and 2,0 billion rubles were spent for technical updating of the operating production equipment, generally for their active part. For the same time labor productivity grew by 53%, i.e. each billion rubles invested in technical updating of production equipment in 1981-1985 gave labor productivity growth only for 2%. To provide labor productivity growth for 200-250% (2,2-2,5 times) it is necessary either with the current efficiency to use the funds in order to increase the amount of capital investments up to 100-120 billion rubles in 15 years which is absolutely unreal, or to increase return from the invested capital up to 14-15% of the gain in labor productivity for each one billion capital investments. It was absolutely necessary to change production and technological structure of capital investments in the industry of prefabricated reinforced concrete, to work out a new developmental scheme for the production of prefabricated reinforced concrete for 1986-1990 and in the long run till 2000 to ensure the necessary amount of capital investments taking into account the realization of the approved by State Committee for Science and Technology and the State Committee for Construction of the USSR target and industry scientific and technical programs within the USSR Construction sector, fundamental technical updating of the active part of production equipment, improvement of social working conditions, improvement of quality and degree of construction readiness of reinforced concrete products and structures, progressive changes in structure and organization of production, improvement of business mechanism in the sector, environmental protection.

Having assessed the state of prefabricated reinforced concrete industry and prospects for its further growth, there were planned the following ways to achieve obligatory indicators for the 90s and till 2000:

- increase in concentration, specialization, cooperation and rational placement of the enterprises in the economic zones of the country will lead to the increase in labor productivity in the sector for 20-30%;

- improvement of production organization, working conditions, methods of planning and economic incentives, widespread introduction of the best practices, improvement of discipline, consideration of social issues can ensure the increase in labor productivity up to 20%;

- improvement of technological processes and the equipment, jointed automation and mechanization of regular and auxiliary productions, increase in technological effectiveness of structures will provide an opportunity to increase labor productivity for 50-60%;

- high-quality repair and maintenance of processing equipment in the set-time limit will allow to raise labor productivity for 10-15%.

The problems of concentration, specialization of new technological processes and equipment which ensure the increase in labor productivity up to 90% have to be solved in interrelation. It can be confirmed by the practices of Head Department of Construction Materials and Products Industry of Leningrad City Council. At its enterprises thanks to fundamental reequipment there was carried out specialization in production and reached the highest in the sector labor productivity. Starting from 1973 to 1980 the author worked in Head Department of Construction Materials and Products Industry of Leningrad City Council as the deputy director of the Design-Technology Bureau (DTB) for science and was responsible for technical progress of the Central board. By 1980, the output of prefabricated reinforced concrete for 1 worker made up 350 m^3/people a year which by 1,5 times exceeded the industry average standards [4].

In 1980, the author was in charge of “Improvement of Factory Technology” laboratory of Concrete and Reinforced Concrete Research Institute of the State Committee for Construction of the USSR and was engaged in technical reequipment of prefabricated reinforced concrete sector in the USSR. Under the conditions of plant concentration, the most economic turned out to be special-purpose line producing 20-30 thousand m^3 of the same products and structures [9].

Overrepresentation by 1986 of the flow-lines can be explained by their adjustability and versatility which gives the chance to effectively produce items of a wide assortment at rather small parties of various brands. Plant concentration, the creation of large special-purpose plants promoted the expansion of application of the conveyor production characterized by the smallest labor input.

When producing elements of large-panel housing construction, battery-mould and bench technology is considered to be more effective than a horizontal conveyor one on a number of factors. Along with horizontal conveyor lines, more economic battery-mould and conveyor lines for vertical casting of flat panels are being adopted. Such line with the capacity of 30 thousand m^3 a year for the production of internal wall panels was mastered, in particular on Kalinin Integrated Home-Building Factory. Bench production will keep the priority in the future for the production of lengthy reinforced concrete products. However, the process scheme should be fundamentally changed. One machine has to serve not one longitudinal stand, but 3-4 stands located in parallel to each other, thus turnover of tooling will reach two times a day.

According to Concrete and Reinforced Concrete Research Institute and All-Union Concrete and Reinforced Concrete Research Institute, the efficiency of the capital equipment in a production cycle on flow-line and conveyor lines is rather low: for vibroplatforms it makes up 25-30% of the general period of line operation, for concrete distributors – 32-35%, for machines smoothing down surfaces – 34-38%. It testifies that most of the time is wasted for manual work, downtime and displacement of moulds. As a rule, manual labour is applied when casting and leveling concrete mix in moulds, when cleaning and greasing of moulds, when removing forms, etc. In new technological lines all operations demanding manual labour have to be carried out by the corresponding mechanisms which period of operation should be closely coordinated with production cycles of other machines operating on the line.

The production of architectural elements of a wide assortment for a change of residential dwellings in the cities and regions can be effectively carried out according to flexible technology. To ensure flexibility it is necessary existence of the retooling forms, stations for retooling, mechanized storages of removable tooling, and also technologically reasonable capacities or application of such process schemes which ensure production of various items without deceleration of production.

The analysis of flexible process schemes applied in the USSR and abroad, as well as again redeveloped schemes taking into account the specified requirements, allowed to establish that technological lines “Partek” with the central cart are the most perspective. Such scheme offers an opportunity to arrange lines in spans of different length, to use bottoms of several standard sizes, and excludes the influence of labor input variation for the production of items on production rate, and also provides an opportunity to retool moulds out of the production line.

At reinforced concrete products plants there was often applied outdated equipment made with the use of obsolete technique. Processing equipment and tooling were insignificantly updated and modernized. The fact that in many cases the introduced equipment didn't give any return testifies to its poor quality i.e. having annual growth in capital labour ratio and mechanization level of prefabricated reinforced concrete plants for 4-6% the capital productivity and production indexes practically remained unchanged.

There are numerous examples of the creation of processing equipment without any involvement of specialized organizations of the USSR Ministry of Building and Road-Making Machine Building Industry or without their approval. As a result, such equipment often had design defects which were being fixed for years, but appropriate samples weren't completed in due time and weren't adopted to a series.

To speed up commercializing of the best equipment samples created by research-and-development and design-and-engineering organizations of various ministries and departments, it was necessary to establish the general order. Prototype models of the new processing equipment before the distribution (even for the relevant ministries) are subject to acceptance for operation in due time with the participation of the leading institutes and the USSR Ministry of Building and Road-Making Machine Building

Industry for the purpose to determinate the appropriateness and an order of their mass production.

To improve the supplying of prefabricated reinforced concrete industry with modern serial equipment it is necessary to organize its production according to technical documentation developed or coordinated by the USSR Ministry of Building and Road-Making Machine Building Industry at the specialized enterprises having necessary capacities and metalworking machines. Using the practices of the advanced construction departments it is appropriate to create modern mechanical plants in the regions across the country in high concentration centers of prefabricated reinforced concrete production [4].

There is a serious concern about welding equipment for reinforcement units produced by the electric power industry. Its shortage makes up from 25 to 70% depending on its type. Such situation forces construction ministries and certain enterprises of the sector to design and create equipment types, non-relevant to their specialization.

For example, over the past few years the USSR Ministry of Construction, Architecture and Housing produced by own efforts 692 units of the procuring and welding equipment at non-specialized plants. Having similar technical and manufacturing capabilities in other construction ministries the common problem of supplying reinforcing floors with the equipment remains unsolved. The solution of this problem lies in integrating efforts and resources – creation of uniform designing system and production of the equipment on modern science and technology infrastructure.

It should be noted that current equipment fleet, including wide-mesh ones is worn-out and outdated. The electric-power industry doesn't produce special-purpose equipment for welding of three-dimensional frameworks, heavy flat frameworks and grids, it doesn't supply the sector with other types of special-purpose equipment. Over a half of three-dimensional, and also heavy frameworks and grids are welded with a manual arc tack or joints by means of additional technological elements in the form of kerchiefs, shovels, etc.

Butt welding machines produced by the industry are designed for welding of reinforcement of A-I - A-III classes. Welding of high-strength reinforcement of A-IU - A-UI classes and especially of thermally strengthened steel is complicated and is practically not possible with the serial equipment. The first contact machine K-724 with wider technological capabilities as a part of the automated line of waste-free steel cutting and bending was launched at Chertanovsky Reinforced Concrete Structures Plant in Moscow.

Significant technological conversion is considered to be the production of welded concrete inserts. Their three-way joints under gumboil are made at the outdated ADF-2001 machine. Solutions on the development and expansion of new equipment are given in table 21.

One of the most effective ways to raise a technological level of prefabricated reinforced concrete industry is a wide use of superplasticizers allowing to considerably cut down on cement, metal and energy consumption, to improve working conditions, to increase its productivity and to save up to 10 rub for 1 m^3 of products. For this purpose since 1986 it was necessary to speed-up in every possible way the creation of plants for the production of S-3, 40-03 superplastisizers, etc., to expand the use of other effective plasticizers, for example, NIL-21, LSTM-2 [7, 9].

Table 21

Solutions on the development and expansion of new equipment in prefabricated reinforced concrete industry

Equipment and technology	Technical and economic indexes for one unit of implementation scope							
	1985-1986	1986-1990	Increase in labour productivity %	Savings of labour input, people	Fuel savings, tons of cond. fuel.	Energy savings, thousand kW/hour	Metal savings, tons	Cement savings, tons
1	2	3	4	5	7	7	8	9
Automated cement storages	420	610	-	-	-	7.5	-	100
Automated aggregates storages	300	520	20	2	-	7.0	-	-
Automated batching equipment with micro-processing technique	-	800	25	2	-	6,0	-	650
Reception,storage and issue depots for chemical additives	400	700	100	1	-	-	-	-
Equipment for cutting and straightening of reinforcement	2655	3290	50-150	0-2	-	-	10-50	-
Fully-mechanized and semi-automated line for piled-plate cutting of reinforcement with the diameter of 40 mm	100	200	200	2	-	60	60	-
Equipment and automated lines for joint welding of reinforcement bars of average and large assortment	830	960	200-450	1-4	-	-	55-130	-
Multiple-spot welders and automated lines for mesh reinforcement welding	1745	2600	50-400	1-4	-	10-100	30-150	-

1	2	3	4	5	6	7	8	9
Machines for welding of tee joints of concrete inserts with anchors of 10-40 mm diameter	2395	2605	80-250	1-5	-	10-100	40-200	-
Installation for bending reinforcement frames	1450	1800	200 - 300	2-3	-	50	-	-
Automated lines for redesigning of prestressed reinforcement, including the use of plasma arc cutting	45	50	100	2	-	-	-	-
Automated line for cutting, bending, prestressing of high-strength reinforcement rods of reinforced concrete slab structures	260	270	150 - 200	3	-	40	40	-
Equipment system for three-dimensional reinforced elements up to 12 m long	460	500	160	5	-	250	5	
Installation for stretching reinforcement rods of 10-25 mm diameter by electrical heating SMZh-429 (Designation of machinery for the production of prefabricated concrete under the classification of the USSR Ministry of Building and Road-Making Machine Building Industry	860	890	50	-	-	25	-	-
Casting equipment:vibroplatforms, including one with the managed mode of vibration	735	1750	50	2	-	16	-	250

1	2	3	4	5	6	7	8	9
Moving casting, including a rolling one	60	155	60	2	-	12	120	1600
Functional moulds of reduced metal consumption and high performance (thousand tons)	10	30	-	-	-	-	200	-
Mass production of the structures and articles with the use of superplasticizers and effective plasticizers (million m^3)	50	73	50	60	-	720	-	35000
Production of prefabricated reinforced concrete and concrete articles based on the use of superplasticizers on casting technique	0,94	1,1	50	120	-	6000	-	40000
Production of prefabricated reinforced concrete with the use of solar thermal treatment (instead of the traditional steam curing one)	2,1	3,7	-	-	35000	-	-	-
Improved (thermal insulated) curing rooms (thousand pieces)	11	16	-	-	30000	-	-	-
Thermal treatment of concrete with the use of combustion products of natural gas	350	700	-	-	22,5	-	-	-
Thermal treatment of concrete with the use of inductive heating	270	340	-	-	450	-	-	-
Conveyor and semi-conveyor lines for the production of prefabricated reinforced concrete structures, including the use of robotic engineering	100	200	30	8	-	5	80	900

1	2	3	4	5	6	7	8	9
Lines for casting without moulds to produce: External wall panels Multi-hollow floor slabs	- 16	6 50	50 70	12 15	8 8	- -	300 300	- -
Battery-mold lines for the production of slabby products, including:								
Lines with the use of easy workable mixes	30	100	30	19	-	12	330	162 0
Lines with the use of moderately stiff mixes	12	25	30	15	-	10	330	200 0
Lines with the use of stiff mixes and industrial manipulators for continuous reinforcement	-	5	40	25	2	10	250	200 0
Bench battery-mould installations with central vibromobility for the production of slabby articles	45	45	15	10	-	5	-	150 0
Universal automated technological line for the production of wall items of a wide assortment made of sand concrete with the use of ash, slag and etc. as aggregates	82	12	120	30	300	20	-	-
Automated line of full factory finishing of wall slabs	20	30	30	8	-	5	-	-
Production of pressure vibrohydraulic compressed pipes with spiral two-way reinforcement	20	3	24	8	150	12	80	-
Automated line for the production of reinforced concrete pressure pipes 300-1200mm diameter by the method of radial press	10	30	120	21	150	12	180	500

1	2	3	4	5	6	7	8	9
Conveyor line for the production of centrifuged tower bodies for public lightning and electrified transportation	-	5	93	26	200	11	200	600

Note:

1. Implementation scope is given according to the data of construction ministries.
2. Improvement of technical and economic indices in 1986-1990 at the expense of recent development is planned to carry out in addition to the specified amount.
3. Economic benefit of above-mentioned solutions:

Index	Unit of measure	Years	
		1985-1986	1986-2000
Economic benefit	Million rubles	680	2255
Savings:			
Labour input	people	25300	35020
Cement	thousand tons	3180	12040
Metal	thousand tons	1130	3720
Fuel	thousand tons of cond. fuel	1440	4920
Electric power	million kW/hour	990	3210

All enterprises producing prefabricated reinforced concrete should be provided with warehouses for storage of chemical additives and installations for their preparation and introduction into mortar and concrete mixes. For this purpose it is possible to use the standard project T.P. 409-28-24 developed by State Design Institute for Building Manufacturing.

It is necessary to speed-up in every possible way the development of serial production of equipment systems by the USSR Ministry of Building and Road-Making Machine- Building Industry on the reception, storage, preparation of water solutions, gauging and handling of superplasticizers to a batching plant which will make it possible to automate the introduction of chemical additives to the greatest possible extent.

It is necessary to develop the use of superplasticizers and other effective plasticizers in the following directions:

- at mass production of products on the flow-line, bench, semi-conveyor and conveyor lines for the increase in mobility of concrete mixes from 1-4 to 5-10 cm with cement consumption for 5-10%, increase in line productivity for 10-20%, change-over of the equipment for low-intensive operating modes. The change-over for concrete mixes with mobility of 15-20 cm with the elements of molding technology is appropriate in some cases;
- in battery-mold and bench production it is necessary to plasticize concrete mixes with the mobility of 5-10 cm with the use of molding technology allowing in case of insignificant cement saving by 2-2,5 times to increase labor productivity of molders and to improve their working conditions;
- in production of items with the use of stiff mixes, including immediate form removal it is appropriate to use plasticizers and to preserve necessary rigidity of the mix for 10-20% of cement saving, improvement of product quality, increase in strength and durability of concrete;
- when producing structures made of high-strength concrete it is necessary to use lubricated blends with the mobility up to 10 cm which will make it possible to obtain the required concrete durability based on cements of lower brands with a considerable decrease in material consumption for the structures.

The possibility for a wide use of additives imposes new requirements to the casting equipment. It is more appropriate to compact workable mixes with the use of symmetric vibration of low frequencies. Decrease in frequency of oscillations from 50 to 15-25 Hz will considerably increase the quality of compaction as the segregation of workable and high workable concrete mixes decreases by 2-2,5 times. Durability of such equipment is 5-10 times higher, and the noise level is 10-15 dBA lower in comparison with the standard vibroplatforms.

The author’s challenges defined the necessity to use low-frequency modes with the frequency of 25 Hz for compaction of concrete mixes which ensured the increase in productivity by 1,5 times. For compaction of stiff concrete mixes there were recommended shock and vibration modes with the frequency of 15 - 25 Hz. The most perspective in this group are considered to be dual-mass resonant vibroplatforms of VRA type with a loading capacity of 5-15 tons [2].

Symmetric platforms with multicomponent nature of oscillations should be referred to the platforms of a frame type. These platforms solve one of the main technological problems of prefabricated reinforced concrete - compaction of concrete mixes in large-size structures. Vibroplatforms of VPK, VO, VPG types with a loading capacity from 10 to 60 tons also refer to this group. These platforms of a frame type perform at the frequency of 24 Hz with the oscillation amplitude in the horizontal plane 0,5 - 0,7 mm, in vertical - 0,3-0,5 mm. The use of oscillations of a multicomponent character provides sufficient technological efficiency for compaction of low-workable and workable concrete mixes. Decrease in oscillation amplitude up to 0,2-0,3 mm makes it possible to cast workable and high-slump concrete mixes of high product uniformity without concrete mix segregation [2, 8].

There are positive practices of production of ridge plates on such vibrotables of 3x12 m in size on Production Association "Kremenchugzhelezobeton". Especially effective is the use of vibroheads from the platforms of a frame type fixed on the stationary forms for production of span slabs of 3x18 and 3x24 m and double slope of rafter beams. Such experience is accumulated at Reinforced Concrete Plant-18 of Head Department of Construction Materials and Products Industry of Leningrad City Council, in Production Association "Ukrpromzhelezobeton", at Kishinev Reinforced Concrete Plant and other enterprises.

The frame type of the equipment, despite its undoubted advantages, demands a large number of standard sizes of vibrotables. That’s why, the USSR Ministry of Building and Road-Making Machne-Building Industry traditionally produces tables of a block type, thus, it is possible to erect a vibrotable with the loading capacity up to 20 t. Vibrotables of a block type with the shock and vibration operational principle represent are of great interest. Vibrotable SMZh-538 refers to such equipment [5].

In recent years there has been developed equipment with the so-called "guided vibration". The guidance lies in the initiating at first symmetric low-frequency, and then symmetric mid-frequency or low-frequency asymmetric oscillation modes. The variable (guided) modes of vibration influence by 1,5-2,0 times reduce the time of vibrocompaction and provide high-quality molding of concrete mixes with the rigidity higher than 100 sec. according to technical viscometer.

The above-mentioned equipment provides ample opportunities for casting enlarged structures according to bench technology, also allows to considerably reduce compaction time at conveyor technology or to increase the rigidity of concrete mixes for technological lines with the immediate form removal.

At the majority of prefabricated reinforced concrete plants there was a situation when the increase in productivity of technological lines was restrained by insufficient capacity of the units for thermal treatment of products. Lack of an opportunity at current enterprises to increase the areas for thermal installations and established practices of fixing of forms and curing rooms determined at many enterprises their single turnover per day. In recent years the specified conditions allowed to introduce moderate modes of thermal treatment with 20-30% of thermal energy savings. At the same time the extended modes became the limiting factor at the increase of productivity of lines.

Nowadays steam heating is a universal way of thermal treatment and this is not quite accurate. In the long run electroheating treatment methods of concrete will prevail in the sphere of thermal treatment. With these methods the process is completely automated, it can be high-accelerated, there is no soaring, losses in thermal energy are reduced. Electric heaters are effective in battery-mold forms, in chambers of tunnel and slot-hole types. In case of heat treatment in packages flat electric heaters are appropriate.

Rather perspective is the heating technology of prefabricated reinforced concrete products in chambers by the combustion products of natural gas. It is known that the gas consumption to obtain the amount of steam necessary for heating of 1 m^3 of concrete makes up 60-70 m^3, and direct use of gas for this purpose and burning next to the chamber reduces its consumption up to 10-15m^3 for 1m^3 of concrete. Such technology is the most effective one in the regions where natural gas isn't hard to find.

In case of thermal treatment of large-size flat articles produced at short benches it is effective to use oil heating which is carried out by the supply of hot oil to the bottom of the bench. Accelerated heating is achieved by the temperature increase of the heat carrier up to 120 °C, and fast cooling is carried out by handling cold oil to the bottom instead of the hot one. Thermal treatment of products according to such technology can be completed in 6-8 h.

Essential reduction in duration of thermal treatment in case of energy savings can be carried out by a wide application of complex chemical additives containing concrete curing accelerator, jet cement with increased heat generation, development of heat isolated casting tooling providing heat conservation in concrete subjected to a short-term thermal impulse.

Stages of prefabricated reinforced concrete development in 1981-1985 and 1985-1986 in the developmental stage demanded a complete elimination of manual non-mechanized labour from production process with a change-over to remote and automatic control of operations. When developing new equipment, there should be immediately taken into account the requirements to its automation.

High level of automation of the enterprises of prefabricated reinforced concrete isn't possible without sufficient production of automation systems and equipment. Nowadays such equipment isn’t manufactured in the sector. The supply of prefabricated reinforced concrete industry with instrumentation, including standard types as well as sensors - measuring converters, and specialized systems of operational and output control.

USSR Ministry of Electrical and Tool Engineering ensures only 90% of demand for devices and automation equipment. The production of some systems and devices is carried out in the quantity of 2-5 pieces a year. The demand for automation systems for thermal treatment and the equipment for calculation of energy consumption (SKRZh, P-3IM, SPURT-1 types, etc.) makes about 4000 units a year. The demand for automation systems of proportioning and preparation of concrete mixes (SUBZ-2, TSIKL-BS types) makes not less than 300 units a year. It is necessary to mass-produce new systems and automation tooling which passed acceptance tests: microprocessor control systems of proportioning and preparation of UD-1 concrete mixes, moisture meters for aggregates, automated quality control stands, etc.

Intensive development of prefabricated reinforced concrete is defined by the system of technical, economic and organizational arrangements focused on the increase in efficiency of capital investments and on a more intensive use of capital equipment of this sector of construction engineering, improvement of the production structure, rational placement of prefabricated reinforced concrete enterprises. And also the increase in efficiency of capacities, economically reasonable level of enterprises specialization and their cooperation in complex deliveries of production to construction sites as well as the reduction of counter and long-distance transportations.

The industry of prefabricated reinforced concrete is not only the main industrial base, but also a basis for scientific and technical progress in construction engineering. However, its managerial and engineering level still doesn't meet modern requirements. One of the main reasons of lagging is departmental disunity of the industry, its design and research organizations. In this regard, the main direction to increase production efficiency of prefabricated reinforced concrete should be considered the improvement of its managerial structure.

Prefabricated reinforced concrete production planning is subject to improvement taking into account not only departmental requirements, but also regional ones. For this purpose, it is necessary to carry out, first of all, certification of all prefabricated reinforced concrete enterprises according to unified scientifically valid system. On the basis of certification results it is necessary to carry out specialization and production concentration, to integrate low-capacity, to close up ineffective and excessive enterprises, to provide high efficiency of available capacities.

The enterprises for the production of prefabricated reinforced concrete are governed by more than 60 ministries and departments. When scheduling the production at the specific plant there are generally taken into account the demands of the superior body and inadequate attention is paid to interdepartmental cooperation. The most important problem of the development of prefabricated reinforced concrete industry is increase of its production concentration, production concentration of mass structures at special-purpose plants in the amounts which ensure to maximum use the capacities and satisfy regional needs for these products having appropriate transportation system. The level of production concentration (average capacity of the enterprise) from 1975 till 1983, for example, in the USSR Ministry of Heavy Engineering increased for 32% (65 thousand m^3), in the USSR Ministry of Farm Building for 162% (34 thousand m^3), at the same time, the level of production concentration in the USSR Ministry of Heavy Engineering is by 2 times higher than the concentration level in the USSR Ministry of Farm Building.

The organization of interdepartmental coordination in the field of sectoral and regional production planning, interdepartmental and intersector cooperation, introduction of new equipment and transfer of the best practices are required. Peculiarity of prefabricated reinforced concrete industry, its role in supplying construction sector with material resources, annual cost of products over 12,5 billion rubles (comparing to the annual production of the large production ministries), big labor and material resources which could be used for the improvement of planning and management of the construction industry of this sector, obviously the creation of the interdepartmental center or any other management structure is required), having all necessary administrative executive functions for the solution of the abovementioned interdepartmental issues.

When planning the development of prefabricated reinforced concrete it was necessary to develop and approve summary balances of production and distribution of the main assortment of reinforced products, both geographically (across federal republics and economic zones), and departmentally. The development of these balances can be assigned to Ministers Councils of Federal Republics as well as interested ministries and departments of the USSR, and their approval can be assigned to the State Planning Committee of the USSR and State Logistics Committee of the USSR. The development of geographical development schemes, construction placement and its material base has to take into account users and suppliers and to include optimizing calculations of transportation schemes for the main construction materials and structures.

It is necessary to put into practice the suggestions made by the State Committee for Construction of the USSR on transportation of prefabricated reinforced concrete and establishment of maximum permissible distance of transportations that would make it possible in the coming years to reduce rail transportation not less than by 20%, and cross-shipments not less than by 2 times. Annual goods turnover of prefabricated reinforced concrete in this case would decrease by 40%, average range of transportations from 830 to 600 km. The analysis of data shows that since 1975 to the present the amount of transportations of prefabricated reinforced concrete remains stable - about 90 million tons a year, i.e. about a third of the prefabricated reinforced concrete structures produced across the country. The average range of transportation of prefabricated reinforced concrete constantly increases: since 1975 it has increased by 290 km and exceeded 800 km.

The analysis of transportation distribution shows that 27% of their amount is carried out for distance more than 100 km and 11% - for distance more than 2000 km, specific weight of the short-range transportations up to 100 km reaches 10% whereas the rational range of rail transportation for mass types of prefabricated reinforced concrete is in limits of 100-800 km.

The comparison of the data for 1975 and 1985 shows that the ratios of export and import were quite steady within the regions. The exception is made by Volga region, North Caucasian and Southwest areas where the negative balance was changed into a positive one. For this period, the excess of import over export in Western Siberia increased by 2,4 times and made up 3 million m^3. Now in this region import makes about 40% of own production. In the North Caucasian, East Siberian, Southwest regions, the Moldavian Soviet Socialist Republic production and consumption can be considered well-balanced. In some regions with negative balance (Volga-Vyatka, Central Black Earth Region) it is possible to meet demands due to the improvement of the available capacities. Within one economic zone there can be excessive and insufficient areas in terms of prefabricated reinforced concrete. For example, in Central region the excess generally appears in Moscow, Moscow region, Tula region, and in other areas import exceeds export.

The characteristic feature of construction placement for the long term which defines the main mechanisms of material base placement is the decrease in types of installation and construction works across the country in case of the accelerated development of eastern regions. Respectively the need for mass types of construction structures increases in these regions, remaining stable in the European part of the USSR.

In this regard, in the European part of the USSR the gain in production of prefabricated reinforced concrete which is required in some regions and areas, can be generally ensured at the expense of production intensification and reconstruction of the operating enterprises, and also deliveries from the nearby regions. Therefore, in this case the problem of placement improvement of the production lies in the determination of rational outputs at the operating enterprises as well as transportation schemes.

At the heart of the required gain in production of prefabricated reinforced concrete, and also deficiency payments at the expense of elimination of worn-out and obsolete equipment, there have to be placed reconstruction and modernization of the operating enterprises, the amount of which has to make not less than 70% of the capital investments allocated for development of the sector.

In eastern regions, first of all, in Siberia and in the Far East where there is planned a rather high construction rate, and production of the structures considerably lags behind the requirements, the issues of placement, capacity of new enterprises and interregional cooperation are rather topical. For these regions it is possible to recommend the following directions of production and transportation development.

Western Siberia has severe shortage in prefabricated reinforced concrete structures, where the demand for them is covered by own production for 60%. However, if we take into account the fact that on biggest part of the region there are no high-quality raw materials for concrete aggregates, and cement and metal production are available only in the southeast of the region, it is advisable to keep in the long term large interregional deliveries from the Ural economic zone having the developed base on production of prefabricated reinforced concrete and having raw materials and materials for their production. Import volume from the Urals to Western Siberia should be kept at the level of 1,5-2 million m^3. The biggest part of these deliveries (1,0-1,7 million m^3 a year) will go to a northern zone. It is possible to recommend also construction of the new enterprises in Western Siberia.

The implementation of the long-term construction program for resources development in the Angaro-Eniseysky region results in a considerable gain in production of reinforced concrete structures in Eastern Siberia. The current material base is capable to satisfy the requirements due to own production and rational use of enterprises capacities. There was appropriate a small scale supply from the nearby areas of Western Siberia (Novosibirsk and Kemerovo).

The main gain in production of prefabricated reinforced concrete in the Far East (600-800 thousand m^3 for 1981-1985) had to be ensured due to the reconstruction and modernization of the operating enterprises. Construction of new enterprises can be recommended only in Baikal-Amur Mainline. Thus, about a third of the production of the Far East region is the share of a northern zone which makes it possible to satisfy its needs without delivery from the southern zones of the region.

In the general system of planning indexes and an assessment of enterprises, associations, ministries (departments) enterprises there was offered the use of conditional and real measuring instruments. The use of real measuring instruments doesn't give the chance to resolve a number of the major issues connected with production planning at various management levels. For example, it is quite difficult to commensurate the technical and economic indices characterizing labor productivity and production at plants and technological lines with various assortment and also it is correct to reflect the high-quality and quantitative changes going on at certain enterprises and in general across the sectors connected with construction needs for specific structures.

When forming up development plans for the sector there had to be considered change in production on each group of structures in order to more reasonably reduce material consumption and labor input for the structures.

In the context of planning and assessing of prefabricated reinforced concrete enterprises activity for an indicator of net production the use of natural measures was not appropriate. It was recommended to use the conditional and real measuring instruments based on labor input for the making of products. It is known that standards of a net production reflect own contribution of labor collectives to production and represent the part of wholesale price of products including the salary, assignments on social insurance and profit. Thus, economic contents of a net production and conditional and real cubic meters are identical, and they could be used for scoping of production, labor productivity, planning of the wages fund and control of its use, and also when assessing activity of the enterprises and summing up socialist competition.

Earlier conditional and real measuring instruments were used only to classify enterprises according to payment categories to pay administration technical personnel, at the same time conditional and real measuring instruments make it possible to reflect output and labor productivity level.

They stimulate the development of new production types and decrease in a material consumption of products, savings of the wages fund, implementation of the plan for the assortment which provides conditions for effective construction structures.

The absolute value of conditional and real cubic meter of the same products calculated for the different enterprises and departments varies. This proves the need to create conditional and real indices in the sector.

The author recommended to centrally arrange work on determination of complexity factors, on the basis of processing and the analysis of the data on the actual labor input for prefabricated reinforced concrete products on the integrated groups applied when developing wholesale prices and standards of a net production.

The conditional and real cubic meter has to be obligatory included in economic part of projects and fabrication drawings of construction structures.

For the realization of available considerable resources to raise labor productivity due to mass distribution and improvement of the best practices it was recommended to join forces of design-engineering organizations of construction ministries and to create interdepartmental center "Soyuzorgpromzhelezoben" for selection and typification of advanced technological processes, equipment, devices, automation equipment and for technical assistance on their spacing and adoption at plants.

To carry out large interdepartmental research, design and engineering and implementation works it was necessary to centralize construction funds of the ministries and departments in the State Committee for Construction of the USSR, and also to create specialized scientific and production association with modern experimental base and experimental plants for equipment production and reinforced concrete products up to full optimization of advanced technological processes and equipment and their release for manufacturing.

6. CONCLUSION

1. The overall output of prefabricated reinforced concrete across the USSR by 1990 exceeded 140 million m^3, including prestressed reinforced concrete – 36 million m^3, among them light and cellular concrete - 40 million m^3. Reinforced concrete is the principal construction material i.e. to its share falls about 25% of total cost for materials and structures in total cost of construction. In residential construction and civil engineering the specific weight prefabricated reinforced concrete use made up over 50%.

It should be noted that the production of prefabricated reinforced concrete in the USA and countries of the European Economic Community made up 35-40% of the total amount. The amount of prefabricated reinforced concrete across our country in total amount of concrete and reinforced concrete exceeds 50%.

2. Prefabricated reinforced concrete sector totaled more than 3 thousand enterprises, and with testing grounds and small enterprises it made about 6 thousand. Capital equipment of the industry makes up 13 billion rubles, and annual production - 12,5 billion rubles.

More than 60% of reinforced concrete was produced at the enterprises with the capacity of 50-200 thousand m^3, about 30% at small enterprises with the capacity of 50 thousand m^3 and only 10% at large enterprises with the capacity of more than 200 thousand m^3. The average output a year for one person made up 219,6 m^3 and over the last 10 years increased only for 2,5%. In Head Department of Construction Materials and Products Industry of Leningrad City Council the average output made 350 m^3. The level of process utilization in prefabricated reinforced concrete industry averages about 80%. Departmental disunity, i.e. subordinance of the enterprises to more than 60 ministries and departments retarded continuous development and increase in labor productivity.

3. In the USSR, the base quantity of prefabricated reinforced concrete i.e. about 60% was produced on flow-line technology, 30% - on bench one and only 10% - on conveyor and semi-conveyor ones. All in all,

there operated more than 24 thousand of technological lines with an average productivity of about 6 thousand m^3. Among them 10 thousand of flow-line lines; 5,7 thousand of battery-mold ones and 8 thousand of bench lines and only about 700 conveyor lines and mills. On these lines there were orerating more than 3 million tons of processing equipment, including molds.

The issues of the development of high-mechanized and automated lines, the use of robots are of current interest. However, according to Japanese experts, the main reasons restraining the introduction of robotics in construction sector are as follows:

- extremely wide assortment of products;
- considerable sizes and mass of construction details;
- big variety and a wide range of production operations;
- poor "feedback" between production workers and developers and etc.

In recent years there have been developing high-mechanized rotor and conveyor and battery-mold lines. However, conveyor principles are reasonable only with technological line productivity more than 20 thousand m^3 of items a year and, as a rule, with special assortment.

4. The basic assortment of prefabricated reinforced concrete articles makes it possible to carry out specialization and production concentration in order to create high-mechanized lines.

In the total amount of prefabricated reinforced concrete flat and linear elements make up about 80% , among them:

- floor slabs, including hollow ones - 33,5 million m^3;
- external wall panels - 26,4 million m^3;
- roof slabs - 13,5 million m^3;
- framework elements - 13,3 million m^3;
- foundation elements - 12,1 million m^3;
- internal wall panels - 11,5 million m^3.

In lightweight concrete structures 85% of all assortment make up external walls, roof and floor slabs. In prestressed structures roof and floor slabs, beams and girders make up more than 70% of the total amount.

5. Annually across the country there was used about 90 million tons of cement for the production of prefabricated reinforced concrete, over 12 million tons of steel and more than 260 million m^3 of aggregates. Cement wasn't efficiently used: the average consumption for 1 m^3 of reinforced concrete makes up about 330 kg, having the average concrete strength about 22 MPa. The use of special cement, especially, rapid-hardening and prestressed ones is insufficient. Modification of concrete with additives is at the level of 40%, and, for example, in the USA it is more than 65%.

The use of reinforcement of A-III and At-IIIS classes with the yield point 390MPa makes up over 5 million tons a year. Its replacement in the structures made of high-strength concrete with the reinforcement of At-IVS class with the yield point 590 MPa will reduce metal consumption of products for 15-20%, labor input for 5-7%.

Widely used for prestressted structures high performance types of reinforcement of At-V, At-VI, At-VII, K-I9 classes and waste-free technologies for its cutting and bending on the automated lines not only significantly reduce metal consumption, but also considerably reduce labor input of production.

It was necessary to point out poor quality of fine and coarse aggregates which often don't meet standards on impurity and fractional composition. Aggregate mixes with the fraction of 5-20 mm are scarcely applied across the country. At the same time, for example, in Finland they apply to four fractions, and in the USA – up to 15 fractions. The use of fractional extraction and washed aggregates saves up to 20% of cement.

6. A wide application of plasticizers gives an opportunity to increase the productivity of technological lines, quality of reinforced concrete products or to lessen cement consumption for 10-15%. Home-produced S-3 superplastcizer ensures the increase in mobility from 2-4 cm of cone slump up to 20-24 cm. Nowadays there has been summed up the experience of this superplasticizer use with concrete and reinforced concrete output more than 5 million m^3.

The highest efficiency of its application i.e. 5-9 rub/m^3 is shown at the production of vibrohydraulic compressed pipes and high-strength concrete. When using S-3 to raise productivity of technological lines, economic benefit makes up more than 3 rub./m^3. But, anyway, its use provided efficiency not less than 1,5 rub./m^3.

In 1986, overall production of S-3 superplasticizer made up over 20 thousand tons. With such quantity of S-3 it was possible to produced more than 10 million m^3 of concrete and reinforced concrete with economic benefit more than 30 million rubles. In the 90s, the introduction of new capacities made it possible to produce up to 200 thousand tons of S-3 superplasticizer a year. The modification by lignosulfonate and development of installations at Reinforced Concrete Plants, especially for the purpose of cement savings is very challenging.

The application of vibration and pulse technology is rather effective (rotor and impulse devices) in technological lines for additives preparation in order to activate the additives when producing concrete. Averaging and activation of additives in rotor and impulse devices ensures additives savings up to 20% and increase in the plasticizing effect for 15-20%.

7. Preparation of concrete mix is one of the major technological operations which can be fully automated.

Nowadays it is necessary to carry out modernization of batching plants with the use of new high-speed mixers, batchers with tensometric sensors, plants for additives preparation. Mixing equipment has to ensure activation of all components of concrete mix and, thus, to ensure separate technology for activation of every component. For example, practices of cement activation in rotor and impulse devices testify to the efficiency of separate technology (10% cement savings).

When updating batching plants, it is necessary to replace concrete mixers SB-35, SB-93 with SB-146, SB-138A mixers and to organize the production of two-shaft tray SB-163. The batchers of ADBU series should be replaced with a tensometric complex (developments of State Design Institute for Building Machine Manufacturing and the Finnish firm "Lokhya"). Finland and other countries' practices have shown the efficiency of computer based calculations in the process of preparing concrete mixes.

8. When carrying out reinforcing operations, welding equipment is in shortest supply of 25-70%.

Decrease in labor input of reinforcing works can be reached due to the following actions:

- standardization of reinforced units at the reduction of standard sizes of prefabricated reinforced concrete articles (the reduction of standard sizes of reinforced products by 2-3 times will reduce the quantity of standard sizes of reinforcement units by 10-15 times);

- automation of reinforcing at production of all types of welded reinforcing grids and frameworks, and also concrete inserts;

- automation of prestressed structures production with the use of DM-2 machines, wire-winding machines, especially with the use of steel-wire ropes of small diameter 7-6 mm.

For example, with the use of DM-2 machine all operations on cutting, bending and tensioning of reinforcement are carried out by one machine. As a result, there increases reliability of technological operations, prestressing variation decreases by 1,5-2 times, overheat of rods is eliminated, the use of DM-2 ensures steel saving of 5,2 kg/m^3, reduction of production costs for 1 m^3 of reinforced concrete about 5 rub/m^3, labor costs by 2,5-3 times;

- replacement of low effective types of reinforcement with more effective ones, use of reinforcement of a screw profile, especially for high-strength steel At-VI and At-VII.

9. Vibrotables are the principal casting equipment across the country. More than 85% of the total amount of prefabricated reinforced concrete is produced with their use. For a long time the main tendency in the development of vibration equipment was the increase of vibration frequency. It resulted in high noise level at prefabricated reinforced concrete plants and low reliability of vibration casting equipment. Vibrotables of SMZh-187A, SMZh-199A, SMZh-200A types with the frequency of 50 Hz can also be referred to such equipment. In the last 10-15 years, development of technological bases of low-frequency equipment with 10-25 Hz frequency range, has started.

Vibration modes of low frequencies: in particular, shock and vibration VRA installations have a high technological compaction efficiency, by 10-15 times lowered power consumption, by 3-4 times higher reliability and make it possible to reduce noise level by 10-15 dBA. In 1985, with the use of shock and vibration technology there was produced about 3 million m^3 of prefabricated reinforced concrete with economic benefit from 1,5 to 5 rub/m^3.

The equipment of Technology Design Bureau Mosstroymaterial (VRA), All-Union Research Institute of the USSR Ministry of Building and Road-Making Machinery (SMZh-538), Central Scientific and Research Institute of Construction of the USSR Ministry of Transport Construction (UVP) belongs to low-frequency installations. For compaction of workable mixes Concrete and Reinforced Concrete Research Institute recommends low-frequency equipment with symmetric oscillations like Poltavsky ISI (UVP). Two tendencies were outlined in technology of prefabricated reinforced concrete.

The first tendency which is (the most widespread) is connected with the use of workable and flow concrete mixes and application of plasticizers. For casting according to this technology there can be recommended any kind of low-frequency equipment and, first of all, the one with symmetric oscillations.

The second tendency considers the use of stiff mixes for the purpose of reduction of molds fleet. For such technology Concrete and Reinforced Concrete Research Institute together with a number of organizations recommended the operated modes. For example, basic vibrotable developed by State Design Institute for building Machine-Manufacturing has two-frequency range (low frequencies will be used for compaction of workable mixes whereas low and average ones for compaction of stiff mixes).

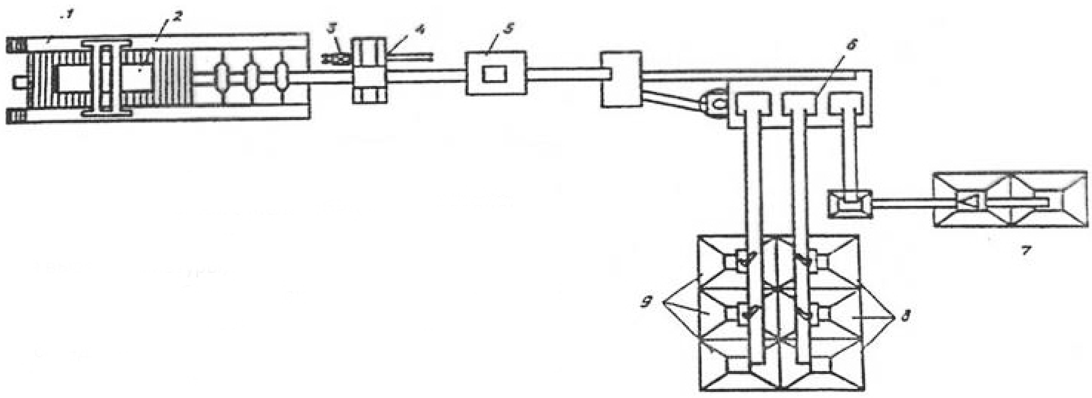
For compaction of stiff mixes, especially fine-grained concrete, there were developed methods of vibropressing and roller casting. For road structures it is recommended to use controlled modes with vibropressing - vibrating presses VIP, NEIL FHM, etc.

10. Nowadays 12 million tons of cond.fuel are wasted for thermal treatment, i.e. about 90 kg cond.fuel for $1m^3$ of prefabricated reinforced concrete. 85% of the total amount of prefabricated reinforced concrete is manufactured with the use of steam heating with efficiency coefficient less than 30%.

To lower heat consumption for 10-20 kg cond. fuel is possible due to:

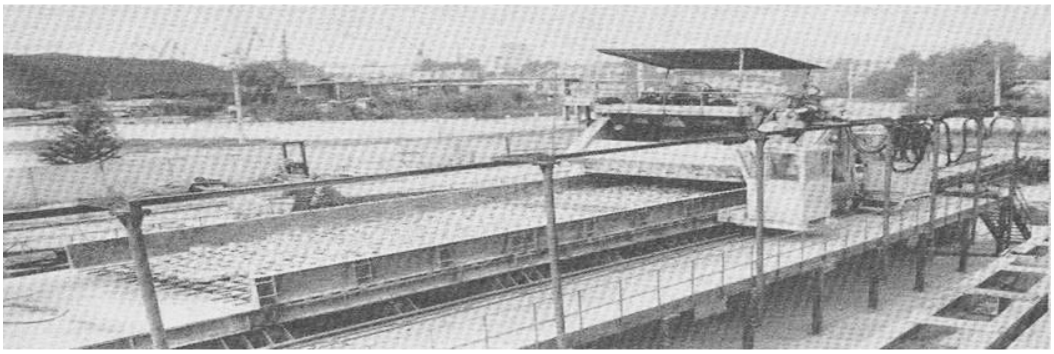
- reliable thermal insulation of steam supply system;
- thermal insulations for enclosure structures of curing rooms;
- monitoring system and system for metering of steam consumption;
- replacement of water with oil in the function of heat-carrying agent.

Electric heat-treatment can be considered one of the most effective methods to intensify concrete hardening. The average power consumption makes up 70-100 kWh/m^3. For 1 kWh the consumption of conditional fuel makes up 0,328 kg. Therefore, 23-33 kg of cond.fuel are wasted for electric heat-treatment for 1 m^3 of reinforced concrete products, i.e. by 2,5-3,0 times less, than in case of steam heating. Economic benefit of electric heat treatment makes up from 1,5 to 5 rub/m^3. Nowadays production of prefabricated reinforced concrete with the use of electric heat treatment makes 5-7% of the total amount or 7-9 million m^3 and will be growing. In the regions of oil development and gas production it is necessary to apply thermal treatment in combustion products of natural gas.



14.Technological line for the production of fractionated secondary aggregate :
1 – installation for primary crushing; 2 – a decomposable off-quality reinforced intem; 3 – magnet eliminator of reinforcement;
4 – carriage for reinforcement; 5 – installation for secondary crushing (jaw-breaker SMD-109); 6 – unit for fine crushing and sorting SMD-27B; 7 – bunker storage for 0-5 mm fraction;
8 – bunker storage for 5-20 mm fraction;
9 – bunker storage for 20-40 mm fraction.

Installation for primary crushing



In areas 50° to the south from northern latitude when reconstructing the enterprises of prefabricated reinforced concrete there have to be widely used production technological schemes with the use of solar technology and mixed technology (with the use of electric energy as the second source).

11. Large resources for the decrease in material and power consumption lie in the use of production waste and by-products i.e. ashes, domain slags, crushed concrete, various microaggregates.

The use of slags and ash makes it possible to save 40-50 kg of cement for 1m^3 of concrete and reinforced concrete. Even greater effect can be expected (according to the USA practices) from the introduction of microaggregates, for example, fine silicon dioxide – ferrosilicon production wastes with the specific surface exceeding a specific surface of cement by 5-6 times.

The reuse of crushed concrete is a great resource. According to the USA data, the cost of crushed tone made of shuttered concrete makes 50% of the cost of the usual crushed stone. In the USA the production of reuse crushed stone reaches 25 million m^3, in the countries of the European Economic Community - 20 million m^3.

In the USSR annual waste of concrete and reinforced concrete was equal 1,3 million m^3, and taking into account dismantling of buildings, temporary roads, the cut-off pile tapping, the amount of failed concrete makes 5 million m^3. Designed equipment and the technological line for concrete crushing with the productivity of 20 thousand m^3 on the basis of UPN-7 installation ensure economic benefit more than 50 thousand rubles a year.

12. Technical reequipment of the enterprises of prefabricated reinforced concrete needs to be carried out on the basis of the created lines, providing the output per capita not less than 550 m^3 of prefabricated reinforced concrete a year.

First of all, these are high-mechanized and automated technological conveyor lines: rotor and conveyor, battery-mold and semi-conveyor ones. There is a positive experience of wall blocks, road, utility rooms and elevator mines production rotor and conveyor lines. Battery-mold lines are appropriate for internal wall panels and floor slabs. Semi-conveyor technologies (with the conveyor of preparation of molds) can be recommended for the production of flat and linear articles (airfield slabs, girders, columns, beams, including prestressed ones).

13. In the modernization process at prefabricated reinforced concrete enterprises it is necessary for construction ministries and departments to ensure priority development of rotor and conveyor technology which makes it possible to eliminate a number of shortcomings inherent in traditional conveyor production and to create conditions for full automation of technological processes. The change-over to rotor technology, in particular, production of road plates provides:

- increase in output for 1 worker by 1,8 times;
- decrease in specific metal consumption of the equipment by 4 times;
- increase in taking-off for 1 sq.m by 4,5 times;
- reduction of a specific electric power consumption by 5,3 times.

14. Production of slabby products for housing construction (panels of internal walls and floor slabs) had to be organized on high-mechanized lines of vertical casting with two-stage thermal treatment. For rational use of production areas the productivity of the line has to be not less than 25-30 thousand m^3 a year. The use of such lines provides decrease in metal consumption of processing equipment by 35%, power consumption and labor costs for 30%, reduction of capital investments for 20-25%. Along with considerable reduction of a number of workers, working conditions significantly improve and the possibility of computer-based automation of all technological processes is provided.

15. The analysis shows that it was possible to raise labor productivity due to the following actions:

- increase in concentration, specialization, cooperation and rational placement of the enterprises which produce prefabricated reinforced concrete in the economic region - for 20-30%;

- improvement of the organization of production, working conditions, methods of planning and economic stimulation, widespread introduction of the best practices, improvement of discipline, taking into consideration social issues – up to 20%;

- improvement of technological processes and equipment, jointed mechanization and automation of regular and auxiliary productions, increase in technological effectiveness of structures - 50-60%;
- high-quality repair and technological service of processing equipment in due time for 10-15%.

REFERENCES

1. Yu.I Bashmakov, Gusev B. V., Zazimko V. G., Osipov B. A. Production of reinforced concrete vibrohydraulic compressed pressure pipes, Kiev, "Budivelnik", 1973, 94 p.

2. Gusev B. V., Deminov A.D., Kryukov B. I., Litvin L.M., Logvinenko E.A. Shock and vibration technology of concrete mixes compaction. Moscow, Stroyizdat, 1982, 150 p.

3. Gusev B. V., Zagursky VA. Concrete reuse. Moscow, Stroyizdat, 1988, 97 p.

4. Gusev B. V. Technical reequipment of the enterprises in construction sector. Moscow, 1988, Znanie, 46 p.

5. Guidebook on casting technology of reinforced concrete products. To Construction Norms and Regulations 3.09.01-85, Moscow, Concrete and Reinforced Concrete Research Institute 1988, 111 p.

6. Gusev B. V., Sokolov V.A. Finishing of surfaces of reinforced concrete products. Moscow, 1988, 39 p.

7. Akhrimenko S. A., Gribanov V. N., Gusev B. V., Ovchinnikov I.P. Methods of quality control and prescription for construction materials composition. Tula, 1990, 231 p.

8. Gusev B. V., Zazimko V. G. Vibration technology of concrete. Kiev, Budivelnik, 1991, 158 p.

9. Gusev B. V., Tsyro V. V., Axelrod E.Z., Tyan V.A. Flexible technology of large-panel housing construction. Moscow, Stroyizdat, 1991, 207 p.

10. 2 Gusev B. V., Yezerskiy V.A., Monastirsky P.V., Kuznetsov N. V. Increase of thermotechnical uniformity of insulated external walls with the ventilated facade. Moscow, Scientific World, 2005, 179 p. (edited by Gusev B. V.).

11. Gusev B. V., Kondrashchenko V. I., Maslov B. P., Faivusovich A.S. Formation of composite materials structure and their properties. Moscow, Scientific World, 2006, 560 p. (edited by Gusev B. V.)

12. Gusev B. V., Samuel Yen-Liang Yin, Kuznetsova T.V. Cement and Concrete: Trends of Development. Moscow, Scientific World, 2012, 134 p.

13. Gusev B. V., Faivusovich A.S. Forecasting of concrete durability when leaching. Moscow, Scientific World, 2014, 69 p.

ABBREVIATIONS:

Gosplan of USSR	USSR State Planning Committee
GKNT of USSR	USSR State Committee for Science and Technology
Gossnab of USSR	USSR State Logistics Committee
Gosstroy of USSR	State Construction Committee of the USSR
Gosstroy of BSSR	State Construction Committee of Belarusian SSR
Gosstroy of Ukrainian SSR	State Construction Committee of Ukrainian SSR
Minstroy of USSR	USSR Ministry for Construction
Minsevzapstroy of USSR	Ministry of Construction in North-West regions of USSR
Minuralsibstroy of USSR	Ministry of Construction in regions of Urals and Siberia
Minyugstroy of USSR	Ministry of construction in the USSR Southern regions
Minvostokstroy of USSR	Ministry of Construction in the regions of the USSR Far East
Minmontazhspetsstroy of USSR	USSR Ministry of Erecting and Construction Works
Mintransstroy of USSR	USSR Ministry of Transport Construction
Minstroydormash of USSR	USSR Ministry of Machine Building for Road and Construction Machines
Minselstroy of USSR	USSR Ministry of Agricultural Sector
CSU	Central Statistics Administration
NPO	Scientific and Production Association
PSO	Production and Construction Association
MGO	Interregional State Association
PO	Production Association
KPP	Large-Housing Enterprise
TP	Territorial Association of Construction Enterprises
PPO	Project and Industrial Association
NIIZHb	Concrete and Reinforced Concrete Research Institute
VNIIZHb	All-Union Concrete and Reinforced Concrete Research Institute
TsNIIEP of House Construction	Central Scientific and Research Institute of Experimental Project of House Construction

Giprostrommash	State Project Institute of Road Building Machinery
NIISP	Scientific and Research Institute of Construction Industry
NIIES	Scientific and Research Institute of Economy in Construction
GPKTI	State Project and Construction Technological Institute
NIL FKhMM and TP	Scientific and Research Laboratory of Physical and Chemical Mechanics and Technological Processes
PI	Project institute
SKTB	Special Design and technological Bureau
SKB	Special Design Bureau
KB	Design Bureau
EKB	Experimental Design Bureau
NS	Outer wall panels
VS	Inner wall panels
BSU	Concrete-mixing unit
ML	Mechanized line
T.P., t.p.	Technological Project
SMZh	Machines for the production of prefabricated reinforced concrete
MTMS	Mechanized Technological machine for Welding
BTC, OBTC	Rapid-hardening and super rapid-hardening cement
RPA	Rotor and pulse device
KSzh, P	Slabs (18-24) m
LEP	Power transmission line
AUP	Production management team
OTК	Quality Management Department

LIST OF CONTENTS

Подписано в печать 06.05.2015. Формат 60×84/16.
Гарнитура Times New Roman. Усл. печ. л. 4,8. Уч.-изд. л. 5,0.
Тираж 1000 экз. Заказ № 594.

Издательский дом «КИТ»
г. Ижевск, ул. Орджоникидзе, 1а