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CLASSIFICATION OF INDUSTRIAL STRUCTURES IN THE SOVIET UNION

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O U T L I N E

I. Introduction

This study is intended as a brief and exploratory attempt to define and classify Soviet industrial structures. It is confined mainly to industrial buildings, thus omitting nonindustrial buildings, as well as structures other than buildings. The procedure followed was first to define the various industrial classification systems and discuss their usefulness and inadequacy. Secondly, industrial structures by structural elements were defined and discussed. In so far as the limited data and resources permitted, the structural elements were used as the basic building block for research.

The bibliography at the end of the report indicates those sources which appeared useful after brief survey, and those which were actually used for the paper. It is clear that on the basis of so few sources, this is in no sense an exhaustive, or even authoritative study. The sources found were of three general types. The first were over-all texts on the construction of buildings, with the discussion centered on each structural element in turn. Such sources usually divided buildings into industrial and nonindustrial, and within these divisions, by one- and multi-story buildings, before proceding to the discussion of the elements themselves. The second type were texts on construction within specified industries. Here the discussion is not necessarily devoted only to buildings but to other industrial structures as well. For example, Chaikin on the building of construction-industry structures discusses quarries and mines as well as shops and plants. The third type of source material approaches the subject from the construction materials side. A single source was used which fitted into none of these categories. This was concerned with the construction of specific model structures, for which the latest labor- and material-saving techniques were used. In addition to buildings, this source was concerned with pipe-lines, electric power installations and blast furnaces.

Because these sources were used as the only ones available for the purpose, something should be said about their reliability as true reflections of Soviet practice. For the most part, these are texts for the use of construction industry students and emphasis is, therefore, more on the best practice than on actual conditions. In addition, some sources concentrate on the great effort for unification and standardization in the construction industry, using examples again from model, or at least ideal projects. The disadvantages of using such sources are obvious. However, since a classification must, of necessity, use typical structures, it is perhaps likely that buildings will follow a model form more often than that they will follow any other single pattern.

Because of time considerations, little or no attention could be devoted to comparing the Soviet material with the United States (U S) or other sources. For this reason it is difficult to ascertain how much of the material presented here is uniquely Soviet practice and how much may have more universal application.

While it is believed that the most useful Soviet sources were used in this paper, it is clear that they are far from satisfactory as a basis for a meaningful classification system of industrial structures.

Since this paper will focus attention on industrial buildings, it is useful to place these in the context of all structures. The following scheme suggests an over-all classification.

Broad Functional Classification [a/]

Nonindustrial			Industrial	
Dwellings	Public service	Commercial	Others	Buildings (see Text)
a) One story	a) Schools	a) Warehouses	a) Pipelines water, gas, oil	
b) Multi-story	b) Libraries	b) R.R. stations	b) Electric power installations	
	c) Hospitals and health	c) Office buildings	c) Mining installations coal, oil, other minerals	
	d) Recreation facilities 1) Buildings: i) Theatres; ii) Museums; iii) Galleries 2) Others: i) Parks; ii) Playgrounds	d) Garages e) Stores f) Restaurants	d) Transport installations Docks, roads, bridges, tunnels, rails	
			e) Agricultural installations silos, animal pens, service areas	

a/ Military installations are given no separate designation but must be subsumed under one of the categories above.

II. Classification of Structures

1. Classification by Industry

Given sufficient information, this might be extremely useful, even though the construction elements within any one industry can be diverse. However, it would be necessary to have assurance that the industry sample was broad enough to include samples of each type of structure . For example, it would not be sufficient to allow a cannery, which is usually a one-story building, to represent the food industry, since meat and fish kombinats frequently are as high as seven stories. In addition, the variety of construction materials, shapes and sizes of buildings is very great in some industries and less so in others. In general, buildings for heavy and medium industries are less diverse than buildings for light industry, with general machine-building industries being the most uniform.

Although there is not a balanced literature sufficient to provide representative structures by industry, certain industries, or individual plants within an industry are analyzed in detail. The information obtained about such industries is given in appendix table A.

It would still be possible to classify structures under broad industry aggregates, even though industries as such would be lost in the scheme. Such aggregates are frequently used in Soviet industrial literature, the most frequent designations for them being a) heavy industry; b) medium industry; and c) light industry. Many of the most important structural elements are distinguishable by these designations, and building design is particularly affected by these categories. In the remaining parts of this section of the study, as well as in the section on structural elements, these designations are frequently referred to. Some of the main differences and characteristics of these three divisions of industrial activity are summarized below.

Heavy industry buildings. Plants producing products for heavy industry are characterized by single-story structures capable of bearing heavy weights for equipment and products. The span of bays is generally wide and the building is usually high, to accommodate for high-capacity overhead cranes. Such plants include those of ferrous metallurgy, open hearth furnaces, rolling mills and heavy forging shops; buildings for electric power plants, and assembly shops for heavy machine building. According to one source, the bays of such buildings are frequently 21 to 31 meters in width and 15 to 33 meters high. There are usually only a small number of bays (1 to 3), with the work flow running the length of the bay (Belenia, pp 16-19). Because of the extreme size of bays, it is preferable to use steel as the main structural material (Shtaerman, p.17).

Medium industry industrial buildings. These include the great majority of general machine building and metal working plants producing general purpose equipment. They too, are usually one story, but with a large number of interconnecting bays. The basic construction material is, today, reinforced concrete, although steel is also used. For both materials, the literature indicates a concerted effort toward unification of construction element types and sizes, with prefabrication of many such elements (see part 3, on classification by building design).

According to Belenia, such plants are characterized by bays 12-18 meters wide and 6-10 meters high.

Light industry industrial buildings. These have the greatest diversity in construction characteristics, but are frequently multi-story buildings, much like office buildings or apartment houses in basic structure. It is not unusual for such plants to have wings of varying height and varying structural materials. Plants in this category include those in the textile, food, light consumer goods, and local construction industries, as well as others. Insofar as possible, the discussion of structural elements in section III of this study indicates the use of each element according to whether the building is of the light, medium, or heavy variety. It should be reiterated, however, that the buildings referred to are frequently only the main production shops. Where no division by these designations is found, it is assumed that medium industry is the pertinent one. A summary of some of the primary differences in structural elements by industry aggregate is given in Table 1 below.

Table 1

Selected Characteristics of Industry Aggregates[a/]

Characteristics	Industry Aggregates Heavy	Medium	Light
1. Sample of industries under specified designation.	Metallurgical; Heavy machinery; Electric power installations; Open hearth furnaces	General machinery; Auto and Tractor industry, Agricultural machinery.	Food and canning; Textiles; Lumber; General consumers' goods
2. Typical bldg. design	— see pages 5 - 10 —		
3. Foundations	Types 3,4, and 5 in table 5	Type 2 in table 5	Types 1 and 5 in table 5.
4. Skeletal structure	Steel (now also reinforced concrete)	Reinforced concrete	Concrete, brick, wood, steel (for multi-story bldgs.)
5. Hoisting equipment	Overhead travelling cranes to 400-ton capacity; girder cranes to 5-ton capacity.	Overhead travelling cranes to 10-ton capacity; girder cranes to 3-ton capacity.	Low-capacity girder cranes or none.

Table 1 (Cont'd)

Characteristics	Industry Aggregates		
	Heavy	Medium	Light
6. Exterior walls	Asbestocement sheet and halfbrick (see pp. 30-33); reinforced concrete wall panels; corrugated steel.	Brick or cement wall panels; brick or cement blocks.	Various (see table A)
7. Floors	Vary according to shop activity (see table 7 and pp.37-38)		
8. Roofs			
a) beams	Structural steel	Reinforced concrete; multi-layered wood; Brick or concrete arches	See table A
b) decks	Reinforced concrete	Asbestocement	Wood
c) roofing material	Corrugated iron or steel; asbestocement	Corrugated iron; ruberoid; asbestocement	Corrugated iron; ruberoid;pressboard;asbestocement;roofing iron, etc.
9. Lighting and Ventilation	see page 43		

a/ For more detail, see under pertinent structural element.

2. Classification by Functional Department

In various industries, the structure or group of structures comprising the industrial installation is made up of a number of functional shops. In general, these may be classified as follows: a) production shops; b) auxiliary shops; c) power plant; and d) storage facilities. The production shops include those producing semifabricates, finished goods, and raw-materials processing.

The auxiliary shops have service functions, such as repair, tooling, etc., and include administrative offices, health and other facilities for the workers. The power supply buildings house electric power plants and may include boiler shops, gas-generating installations, compressors, etc.. Storage facilities contain raw materials and other supplies, semifabricates and finished products awaiting shipment.

The advantages of this classification are many. Production shops could be grouped according to the size and weight of production machinery, or the size and weight of product (these usually bear some relation to each other); auxiliary shops could be of unified construction, given an optimum plant size for many industries grouped together. The same could be said for the other shops mentioned above. Unfortunately no literature was found to facilitate this classification. In fact, there was a total absence of literature on any but the main production shops of plants, except that where only one building housed all shops, this was sometimes distinguishable. In part III of this study, in the section on flooring in construction industry shops, there is an example of what could be done with this type of classification, given the proper data.

3. Classification by Building Design

By design, industrial buildings may be a) single story, single bay; b)single story, multi-bay; c) multi-story, single bay; d)multi-story, multi-bay; e) combinations of irregular heights and numbers of bays. The designation bay refers to the interior divisions of the shop, which may be defined either by a series of columns running the length of the building, or by more solid partitions.

In addition, the buildings may be simple rectangles, U-shaped, L-shaped, etc. Certain generalizations may be made on the basis of this classification, but they are subject to a great deal of qualification. For example; multi-story buildings are most common in those branches of industry producing light-weight articles on light-weight equipment, or when the vertical is made use of in moving materials by their own weight (such as mills, grain elevators, crushing installations, etc.). According to one source (Osipov, p.279), such buildings are rarely wider than 36 meters and the height of the stories (which vary in number from 2 to 6, and sometimes more), is from 4.2 to 4.8 meters.

Because of the wide use of single story industrial buildings, and certain features common to most of them, there has been an attempt to unify their parameters, in definition at least. According to Osipov, the following parameters are generally accepted for reinforced concrete buildings, and many structural elements are prefabricated in accordance with them.

> Distance between supporting columns—6 and 12 meters
>
> Width of bay—6, 9, 12, and 15 meters for narrow buildings and 12, 18, 24, 30, and 36 meters for the larger buildings.
>
> Height of bays--without cranes, 4, 5, and 6 meters (measured from the floor to the lowest roof supports) and with cranes, 6, 8, 10, 12, and 14 meters (measured from the floor to the end of the crane rails); the distance from the end of the crane rails to the roof support depends on the crane dimensions, but is commonly a multiple of 0.2 meters.

According to another source concerned with steel structures (Belenia, pp 19-20), the optimal distance between supporting columns is 12 meters; width of bay, 18 meters and height of bay, from 6 to 8 meters.

Unified parameters have also been accepted for certain multi-story industrial buildings (Osipov, pp. 288-291); namely, those in the food and other consumer-goods industries. These have the following unified characteristics.

They are made of precast reinforced concrete elements in sections 36 meters wide and 42 meters long. The network of columns are in 6 X 6 meter squares. The buildings are 4-5 stories high; the height of one story, measured from floor to floor is 4.8 meters (except the basement story which is 3.6 meters).

It is possible to relate building design to the broad industry aggregate classification discussed above. In general, medium and heavy industry plants are single story; plants in light industry may be single or multi-story. In general, heavy industry plants have less than 3 spans; medium industry plants will be more likely to have a greater number of spans. A few specialized plants are of the single span, multi-story type, and some have a combination of heights and spans (for example, a cement plant may have several stories in the mixing shop to facilitate pouring from a mixer on the upper floor to containers on the lower floor, whereas the rest of the production department may be situated in one-story shops on either side). The amount, if not the type, of construction material is certainly affected by the choice of building design, so that this classification has significance. However, it cannot stand alone. For example, a single story, single span building may or may not be suitable for heavy industry, depending on whether it is made primarily of steel or concrete, or whether it is high enough and wide enough to contain high-capacity overhead cranes.

4. Classification by Construction Material

Although industrial buildings cannot be said to contain only one construction material, it is possible to characterize them by the material of their framework or carcass. Thus buildings may be described as primarily of a) wood; b) concrete; c) brick; d) reinforced concrete, monolithic or precast; e) steel; and f) stone. This classification is not, however, very useful in itself. The most that can be said is that steel is primarily recommended for heavy industry plants where bays are high and wide; wood, brick and stone are used almost exclusively in light industry (wood, in particular being used for small, local plants, although certain parts of all industrial buildings could profitably use it); and reinforced concrete is gradually becoming the primary basic construction material for all industry except the very heaviest.

5. Classification by Structural Element

Because of the variety of ways in which structures might be classified it seemed best to choose the method which best fit into the organization pattern of the literature. In general, whether discussing industrial buildings as a group, or the structures of a particular industry, much of the material was outlined by structural element. In addition, a discussion by element made it possible to sub-classify by construction material, thus incorporating at least one other classification system. In choosing this method, an attempt was made in addition to distinguish industries, at least insofar as they might fit into the areas "light", "medium" and "heavy".

By viewing the material in terms of elements, it became apparent that much emphasis was placed on the relatively recent use of prefabricated, standard size elements; particularly those of precast reinforced concrete. The following tables should be of interest in indicating just how far this tendency has gone in some branches of industry.

Table 2

Percentage of Prefabricated Elements by Industry, 1951, 1953, 1956

Industry	Degree of Prefabrication (%)		
	1951	1953	1956
Metallurgical and Chemical	40.3	42.7	53.7
Machine Building	42.6		46.8
Petroleum	48	46.5	53.4 a/
Coal	n.a.	21.3	31.8
Transport	15.6	16.2	19.6

Source: Syrtsova, p.33

a/ Including pipe.

Table 3

Indicators of Prefabrication by Type of Construction Material

(Per 1 million rubles of construction cost)

Type of Material	Metallurgical & Chemical	Machine Building Industry
Metal structures (tons)		
1951	68	33.3
1955	45	31.3
1956	62.2	27.6
Reinforced concrete (m^3)		
1951	32.3	33.7
1955	57.9	87.6
1956	122.9	150.7
Wood structures and parts (m^3)		
1951	139.4	174.9
1955	103.5	112.3
1956	154.4	120.8
Cement, solid and blocks (m^3)		
1951	51.8	50.7
1955	35.7	27.5
1956	53.7	47.8

Source: Syrtsova, pp. 33-34.

6. Other Possible Classifications

Because of the special requirements necessary, buildings could be classified by types of intra-plant transport, and hoisting equipment; heating and lighting facilities, etc. Obviously, these characteristics are not sufficiently universal in influence to be the basis of classification. They will, however, be discussed as though they were structural elements like walls or roofs.

III. Structural Elements

1. Foundations

The type of foundation, and material used for its construction, depends initially on two factors: the softness, or resistance of the ground, and the weight of the structure resting on the foundation. As a general rule, the weaker the ground and the heavier the weight upon it, the greater the amount of foundation material needed. Table 4 indicates the desirability of using certain materials at various pressures.

Table 4

Factors for Selection of Foundation Materials Under Columns with Weightload in Tons

Admissable pressure on the ground (kg/cm2)	Reinforced concrete	Concrete	Rubblestone
1	Only reinforced concrete	---	---
1.5	When weightload is greater than 60 tons	Weightload less than 60 tons	---
2-3.5	Weightload greater than 250 tons	Weightload less than 250 tons	Weightload less than 50 tons
4-4.5	---	Always profitable	Weightload less than 150 tons

Source: Shtaerman, p.34.

In addition to the materials listed in table 4, foundations may be of brick, stone or wood (for some light industry shops, or auxiliary shops).

Reinforced concrete foundations may be either precast or monolithic, that is, cast on the site. In the most recent literature, it is clear that heavy emphasis is placed on reinforced concrete precast foundations for almost all industrial building.

The amount of concrete, or other construction material used, depends on whether the building has a single span, or bay, or multiple bays, or whether the load on the foundation is great, making it necessary to reinforce foundation posts with connecting strips. Table 5 indicates some of the varieties to be found in industrial building foundations. It should be noted that special features of soil, climate and natural phenomena may have an effect on the type of foundation used. Particular problems exist in areas of permafrost, or seasonally frozen ground, areas of seismic activity, marshland, waterfront areas, etc. Foundations to cover these environmental factors cannot be covered here, but are noted in the classification in table 5.

Table 5

Types of Foundations

	Characteristics	Uses	Materials
1.	Basement type: foundation serves, at the same time for basement walls	Mainly light industry where basements exist	Brick, stone, concrete
2.	Footings for columns which are placed at regular intervals to support exterior walls and roof beams. The exterior footings are connected by foundation beams. In multi-bay shops, columns which divide bays have footings also.	Standard construction; average pressure and weight	Concrete, reinforced concrete, steel, pile, quarrystone
3.	Same as 2, with extra footings under heavy machinery	For shops with concentration of heavy machinery	Concrete, reinforced concrete
4.	Same as 2, with strips joining all footings in one or both directions	For shops where ground resistance is low and load heavy	Concrete, reinforced concrete, steel pile
5.	Same as 2, except solid slab beneath footings	For multi-story buildings or when ground resistance is low and load is extra heavy	Concrete, reinforced concrete, steel pile
6.	Special foundations	For conditions of weather and environment, such as permafrost, volcanic areas, earthquake zones, etc.	--

Sources: Osipov, Shtaerman, etc.

Figure 1

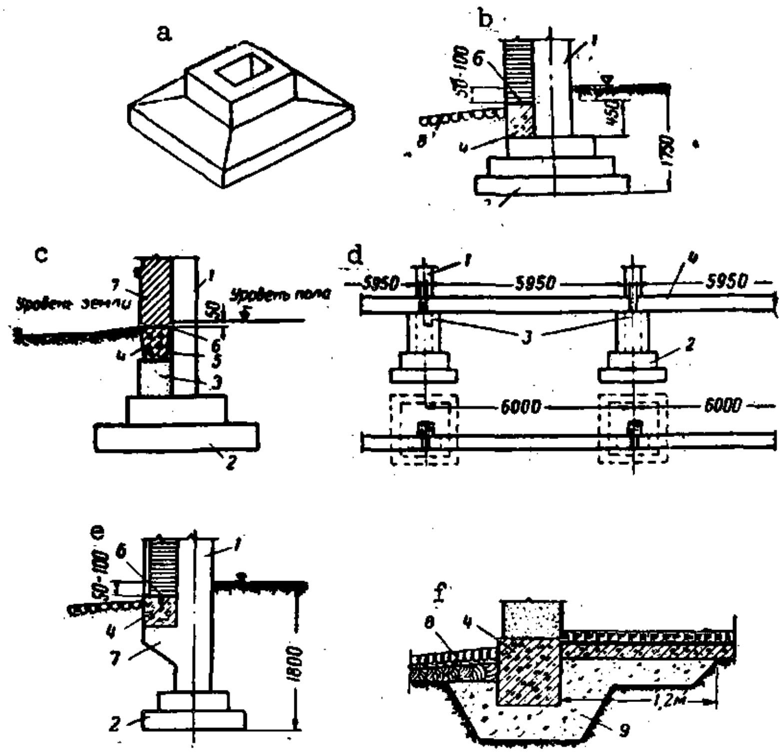

Рис. 230. Design of industrial foundations

(a) Foundation of footing type.

(b) through (e) Depict various ways that (a) may be used.

(f) Is a slag bed type foundation.

<u>Source</u>: Osipov, p.293

Figures 2 and 3

Fig. 2 →

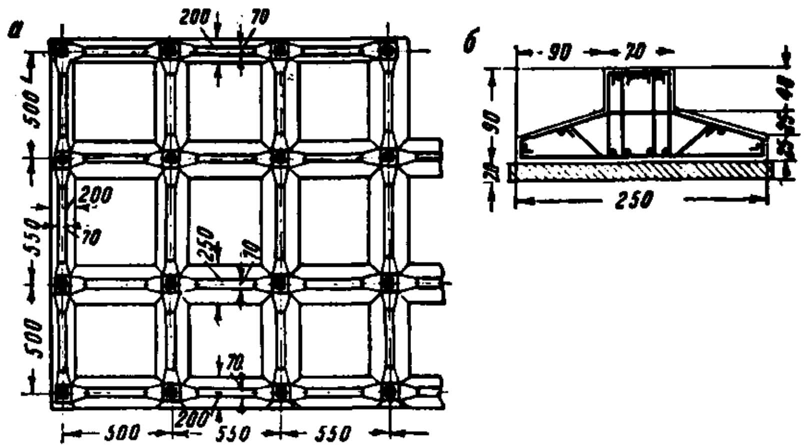

Рис. 20. Ленточный фундамент в плане (*а*) и в разрезе (*б*).

Fig. 3 →

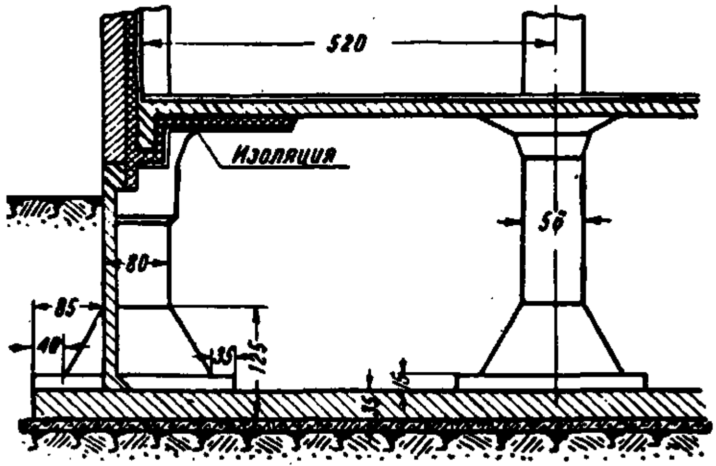

Рис. 21. Сплошная безбалочная железобетонная фундаментная плита под многоэтажным холодильником при слабых грунтах,

Fig. 2 - Foundation of type 4 (see Table 5)

Fig. 3 - Foundation of type 5 (see Table 5)

Source: Shtaerman, p. 33

Figure 4

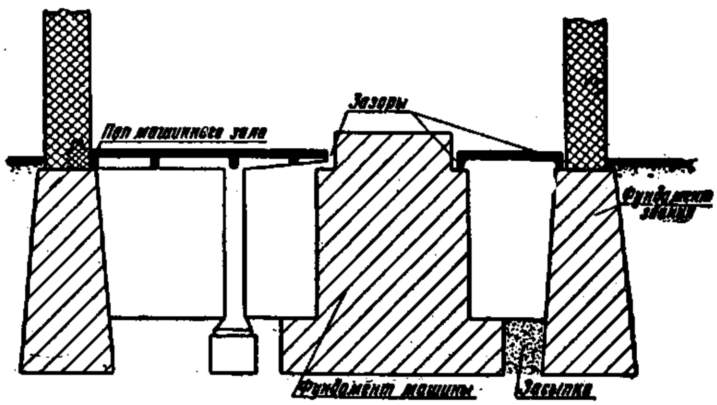

Рис. 31. Схематический разрез через машинный зал.

Foundation of type 3, foundation under machinery (see Table 5)

Source: Shtaerman, p.42

2. Skeletal Structure

For industrial buildings, the material of which the skeleton is composed is pretty well limited to steel (most advantageous for multi-story buildings and single-story shops in heavy industry), reinforced concrete (now apparently used wherever feasible in all types of industry), and wood or brick (only used in light industry). The skeleton consists of the columns which support the superstructure and, to some extent, the exterior walls; the inner columns which divide bays, the crane rails, if any; the roof trusses and the other beams and girders on which upper floors and roofs rest. Loads from exterior walls are, in most cases, transmitted to foundation columns through base beams. In connection with the standardization of much of the skeletal structure, reinforced concrete foundation beams are standardized at a thickness of 450 mm., and are of 3 widths: 300, 400, and 520 mm. (these are, according to Osipov the most common thicknesses of exterior walls in industrial buildings); these beams are placed 50 mm. below floor level, which, in turn, is planned at 150 mm. above ground level (very deep foundations are as much as 1800 mm. below the floor). The reinforced concrete skeletal elements may be either precast or monolithic, or a combination of both.

The columns along the periphery are joined by longitudinal beams which serve as support for the wall filler. These beams are standardized at a thickness of 490 mm. and a width of 200, 250 or 380 mm. The length depends on the distance between columns. These beams are commonly faced with sheet steel.

According to the same source, steel skeletons have the same construction design as reinforced concrete. The columns may be solid beams or several vertical sheets welded together (the foundation beams are reinforced concrete).

Industrial buildings with steel skeletons are also built with standardized parts. According to Belenia, they are of two types: one with conveying equipment (overhead) up to 5-ton capacity, distance between columns of 12 meters and bays from 12 to 24 meters; the second, with overhead travelors of 10 to 50 ton capacity; distance between columns of 6 meters and bays from 15 to 24 meters.

The first type is typified by universal machine building plants, according to Belenia, p. 35. Very heavy cranes, of capacity from 100 to over 300 tons, present special problems (see the next section for the influence on structure of hoisting and conveying equipment). According to Belenia, p.61, the steel skeleton of plants in heavy industry can weigh from 200 to 400 kg. per square meter.

In general, as indicated earlier, steel can bear heavier weights and is used in plants in heavy industry; those in medium industry use reinforced concrete skeletons, and those in light industry, steel, concrete, and sometimes wood (see table A).

Figure 5

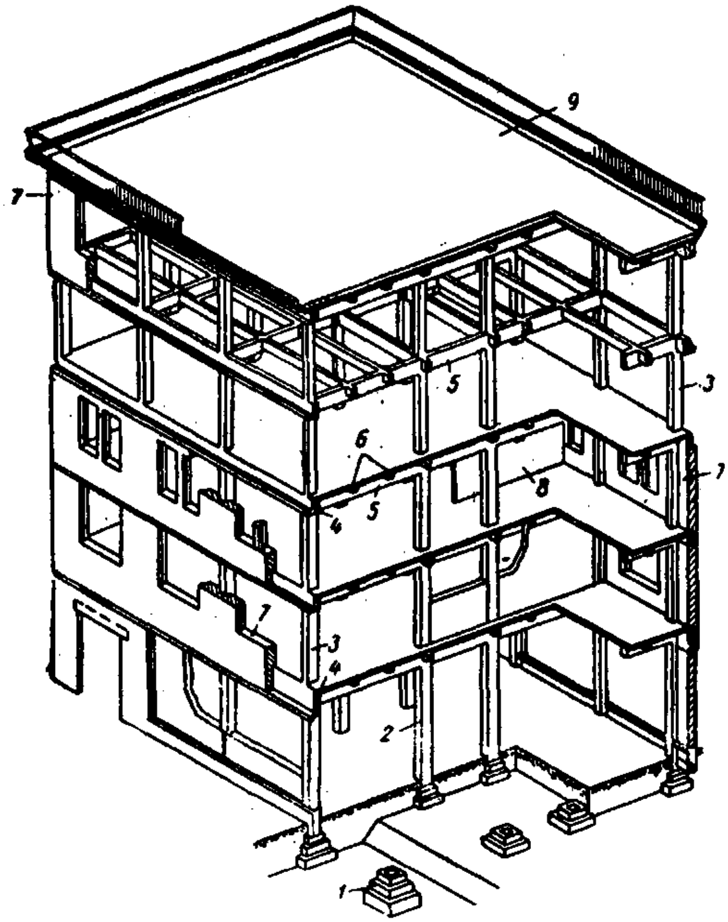

Рис. 6. Схема каркасного здания

1 — фундаменты; *2* — внутренние опоры (колонны); *3* — наружные колонны; *4* — бортовая балка; *5* — прогон; *6* — балки перекрытий; *7* — стеновое заполнение; *8* — перегородки; *9* — плоская крыша

Figure 5. Design of Building Skeleton

1. Foundation
2. Interior columns
3. Exterior columns
4. End beams
5. Purlins
6. Floor beams
7. Walls
8. Partitions
9. Flat roof

Source: Osipov, p.22

Figure 6

На рис. 9 в отличие от примера на рис. 8 наружная стена не передает своей нагрузки колоннам, а расположена впереди них и является самонесущей, опираясь или на самостоятельный фунда-

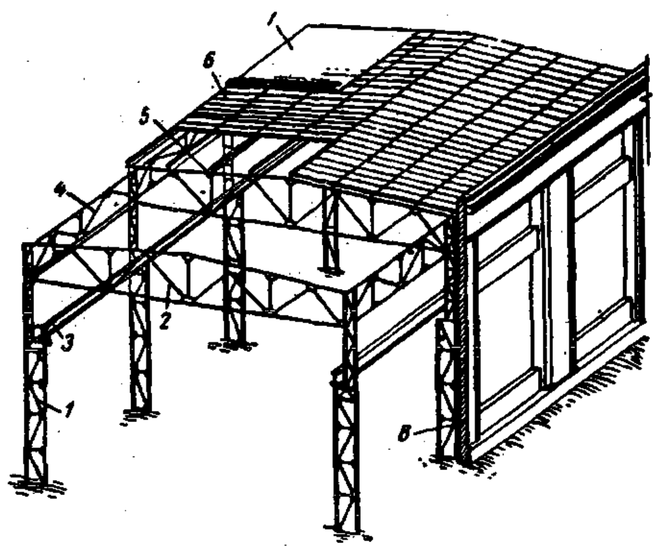

Рис. 9. Конструктивная схема одноэтажного однопролетного промышленного здания со стальным каркасом

1 — решетчатая колонна; 2 — стропильная ферма; 3 — подкрановая балка; 4 — решетчатая связь; 5 — прогоны покрытия; 6 — плиты покрытия; 7 — кровля; 8 — самонесущая стена

мент, или через фундаментные балки на фундаменты колонн. Устойчивость стены обеспечивается соединением ее со стойками каркаса специальными креплениями.

На рис. 10,*а* показан поперечный разрез многопролетного про-

Figure 6. Steel skeleton of one-story industrial building.

1. Lattice girder columns
2. Roof trusses
3. Crane-supporting girder
4. Trusses
5. Roof purlins
6. Roof deck
7. Roofing
8. Walls

Source: Osipov, p.26

3. Hoisting and Conveying Equipment

The following table indicates the influence that hoisting and conveying equipment may have on various structural elements.

Table 6

Hoisting and Conveying Equipment

Type of equipment	Structure affected	Special installations required
Vehicular (incl. hand-carts, auto and electric cars, r.r. platforms)	Floor	Roads and r.r. track
Mounted (incl. ground-type conveyors, escalators, elevators, etc.)	Floor	Stand or housing
Girder and overhead travelling (incl. girder cranes from 1 to 5 tons and overhead travellors from 5 to 400 tons)	Columns and walls	Reinforcement of columns and walls and crane support beams
Cantilever (incl. cantilever and revolving cranes, etc., fastened to walls)	Columns and walls	Reinforcement of columns and walls
Suspended (incl. telphers, trolley conveyers, monorails, and overhead girder cranes up to 10 tons and sometimes more)	Roof trusses and columns	Reinforcement of trusses
Other	Various	Various

Source: Belenia, p.22.

In general, buildings which need overhead travelling cranes need much reinforcement and require large expenditures of steel. The weight of such buildings can be 300 kg/m^2, and higher for open hearth furnaces (Belenia, p.61). Since the use of such cranes is limited to medium and heavy industry, it is interesting to note that, in an analysis of 22 plants in the auto-tractor and machine building industries, 65% of the production area is serviced by cranes of less than 5-ton capacity, and 85%, by cranes with under 10-ton capacity. (Belenia, p.24). In general, these may be considered medium industry plants. They are serviced, according to Belenia by overhead travellors of from 3 to 10 ton capacity and girder cranes of 1 to 3 ton capacity. Belenia recommends the substitution of suspended-type hoisting equipment for the overhead travellors. He indicates that they not only save on metal, the construction complications in the installation of crane rails, and the lighter load on the foundation and columns, but also allow for more maneuverability in the shops. He limits this, however, to medium machine-building shops, with distance between columns of 12 meters. However, for heavy industry, he advocates the same substitution by using a radical shop design, in which the hoisting equipment rests on its own foundations. See figures 7 - 10 for some of these designs, none of which, as far as can be ascertained, have yet been adopted.

Figures 7 and 8

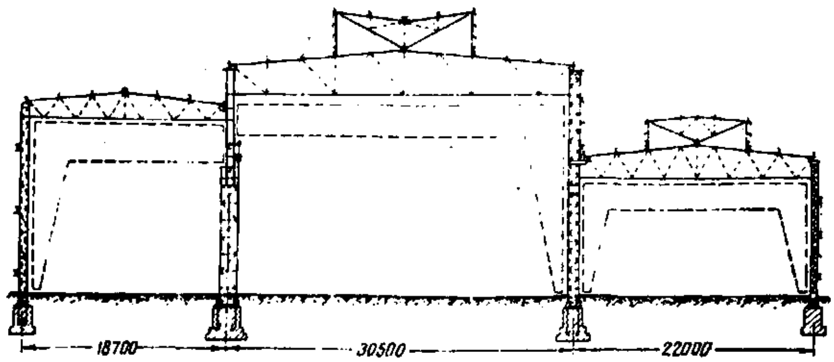

Рис. 36. Поперечный разрез здания блюминга с козловыми кранами

Figure 7. Lateral View of Blooming Mill with Gantry Cranes.

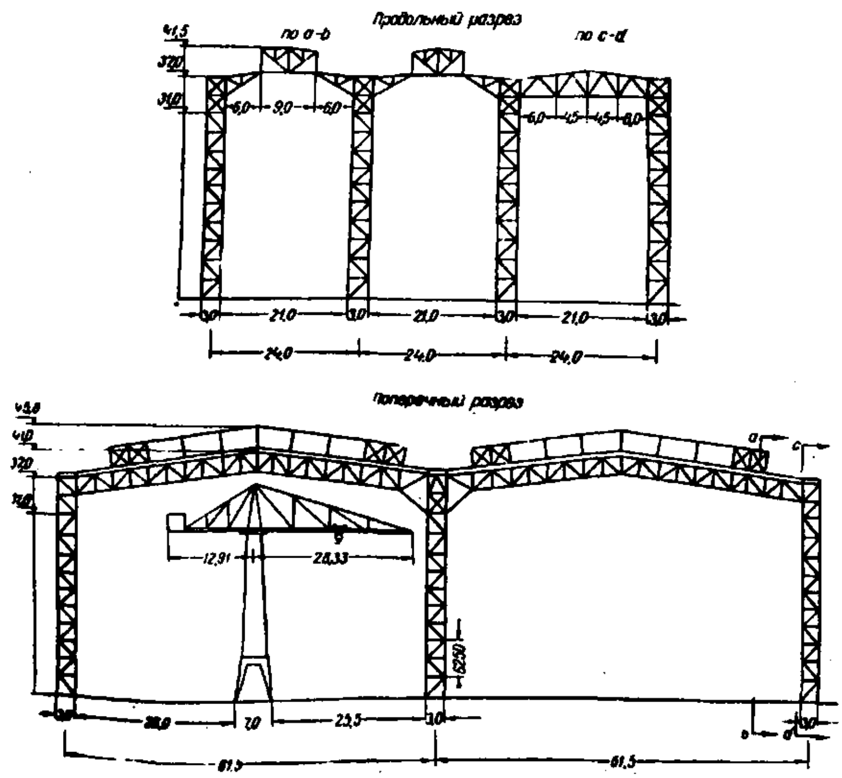

Рис. 37. Здание судостроительного сборочного цеха с башенными кранами

Figure 8. Ship-Building-Assembly Shop with Tower Cranes.

Source: Belenic, p.67

Figure 9

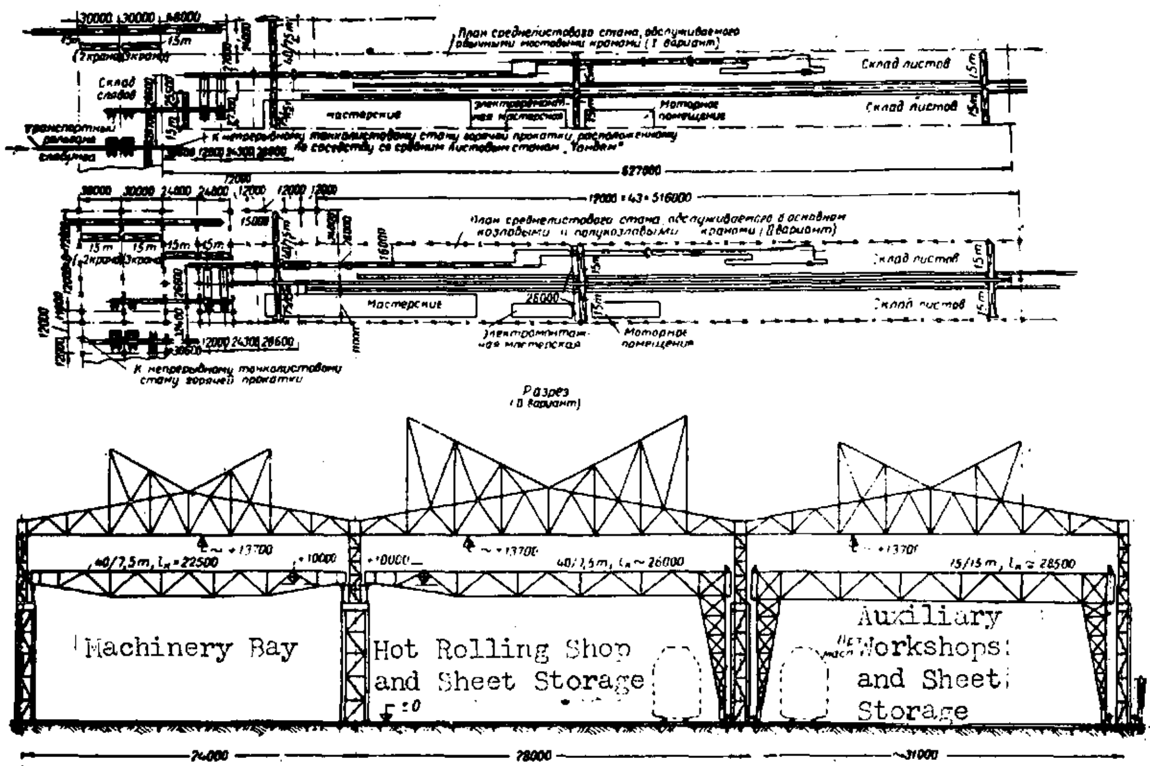

Рис. 35. Технологическая схема здания листопрокатного цеха с козловыми кранами

Figure 9. Metal Sheet Rolling Shop with Gantry Cranes

<u>Source:</u> Belenia, p.66.

Figure 10.

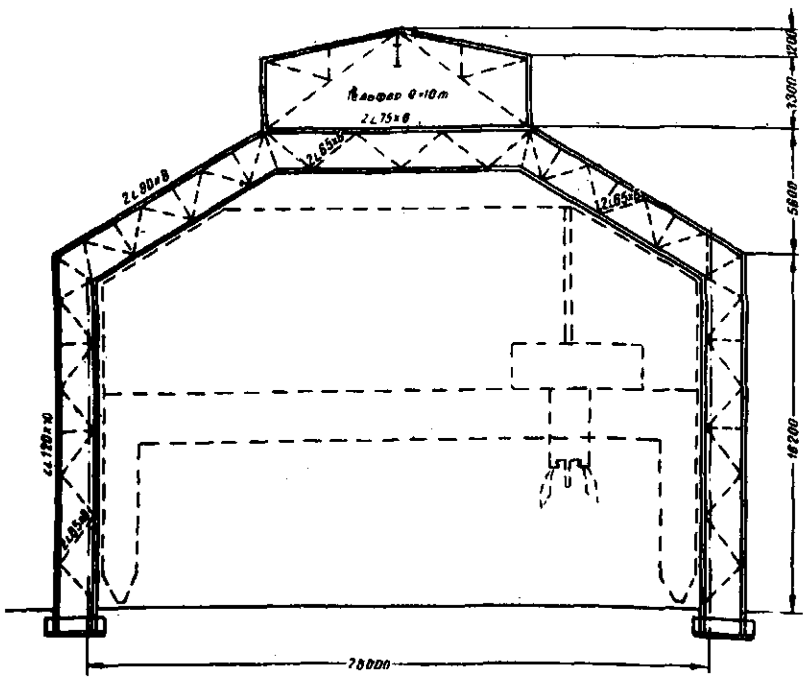

Рис. 34б. Схемы стрипперного здания с козловым краном

Figure 10. Stripping Mill with Gantry Crane

<u>Source</u>: Belenic, p.65

4. Walls

According to Osipov, industrial buildings have walls of various kinds of brick, small or large cement blocks, asbestocement sheet and large panels of various materials. There are, of course, other materials too: metal, wood, reinforced concrete, etc. An idea of the varieties used for some industries is given in table A. The thickness of walls depends to some extent on whether buildings are heated or unheated. Osipov says that for heated buildings,walls are from 250 to 500 mm. thick, but can be much less for unheated buildings, or those in which the production processes are themselves heat producing. For multi-story buildings, or high one story buildings with heavy crane or other equipment, walls are reinforced by cross-beams fastened to the exterior columns, or by a lattice work of reinforced steel or concrete beams. Shtaerman indicates that such reinforced walls are only used in one story buildings if the height of the shop is 5-8 meters, and if the heating requirements necessitate the use of walls 1 to 1-1/2 bricks thick. Such walls are also used in the food industry for multi-story buildings of sugar refineries, extraction plants, etc. In general, the reinforcement (equivalent to an additional skeleton) is reinforced concrete or steel.

Wooden walls. Table A indicates where these are most frequently used. There is emphasis that they are only desirable in richly forested areas.

Asbestocement sheet. This is recommended for walls of unheated buildings, or those with heat-inducing production equipment. Even so, the lower part of the walls, subject to the most stress and moisture should be made of brick or other durable material to a height of 2-3 meters above floor level (see figure 11). The standardized dimensions of such sheet are: 1600-2100 mm. in length, 1040 mm. wide and 6 mm. thick.

Brick. A widespread wall material as indicated in Table A, whether light, medium or heavy industry.

Brick or cement blocks. This is considered highly desirable in heated buildings; the blocks are brick, light or porous cement, or a silicate mixture. Standard sizes are: length: 1, 1.5, 2, and 3 meters; height: 0.6, 1.2, and 1.8 meters; thickness: cement--300, 400 and 500 mm.; brick--250, 380, and 510 mm. According to Shtaerman, they are used primarily when plants of the same type are produced in numbers, and heavy hoisting equipment is available.

Large wall panels. These are a recent development. They are made of brick, cement, reinforced concrete and combinations of cement-concrete-silicate mixtures. Panels may or may not be insulated, and may or may not be single or double layer. Single layer panels, according to Osipov, are most satisfactory when made of reinforced autoclavic foamy cement, weighing from 700 to 900 kg. per m^3. The thickness of the panels depends on the outside temperatures and the heat requirements of the plant. Foamy cement panels of 800 kg/m^3 and an outside temperature of -30° centigrade, must be 200-250 mm. thick. Double layer panels are reinforced concrete slabs, insulated with cement or other material. Reinforced concrete panels uninsulated are used for walls of unheated buildings. Brick panels are of two types: blank, or with window openings. One panel is a brick slab, 5.98 x 2.84 meters; one-half brick thick, with ribbed columns one brick thick at top and bottom. Above and below the panels are reinforced concrete connectors. Such panels may also be insulated or not.

Concrete. These walls are reinforced or not, but are monolithic (reinforced concrete precast is in the form of slabs or panels mentioned above).

Other materials. As indicated in table A, walls of some temporary buildings are metal, and of some small and light-industry plants, stone. In general, local industry (which is usually light) makes use of local construction materials for walls, as well as local insulating materials, such as peat.

According to Belenia, walls of unheated buildings (usually heavy industry where technological processes make heat) are usually corrugated steel or asbestocement with half-brick (see figure 11).

Figure 11

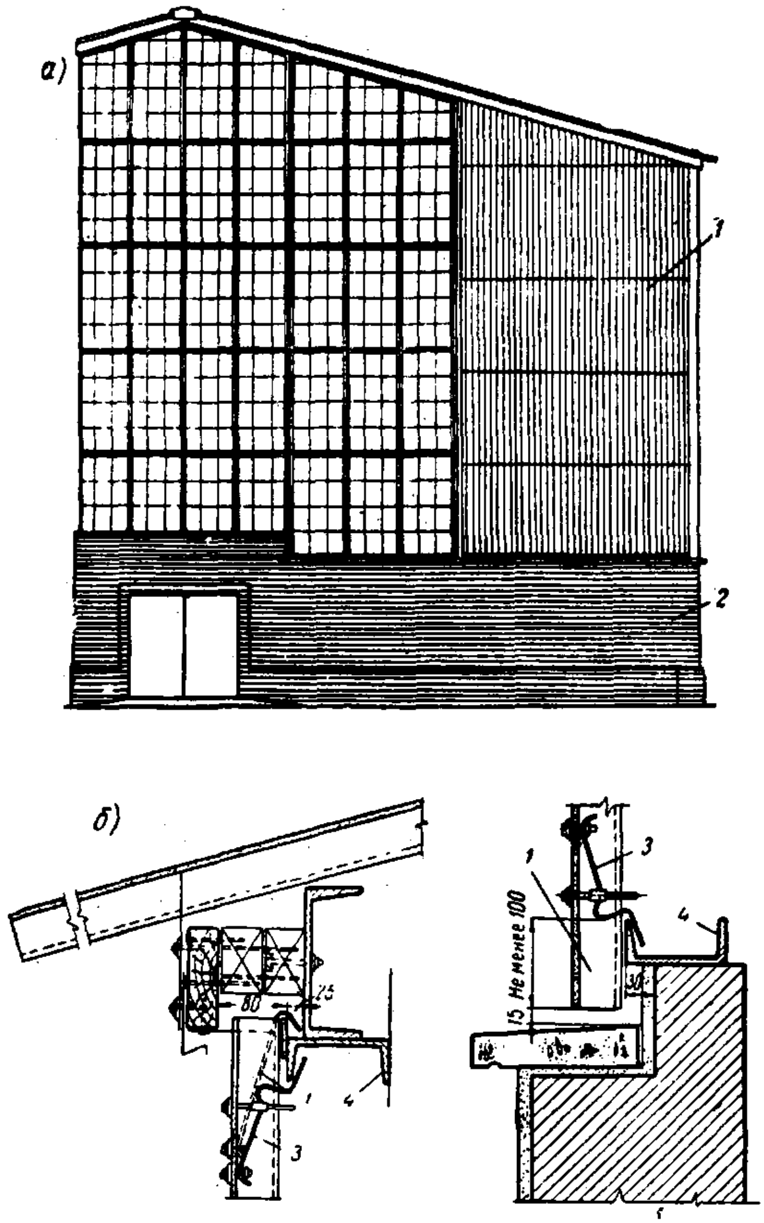

Fig. 11 Walls of Asbestoscement*

а — общий вид; б — крепление листов к фахверку; 1 — асбестоцементные листы; 2 — кирпичная кладка; 3 — кляммера; 4 — ригель фахверка

Figure 11. Walls of Asbestoscement

1. Asbestoscement sheet
2. Brick masonry

Source: Osipov, p.300

5. Flooring

Floors are made of a wide variety of materials including earth, adobe, asphalt, cement, concrete, wood, metal, tile, cinder brick, and linoleum. Many of these varieties are laid over a layer of cement. Undoubtedly there are many other materials and many varieties within each of these categories. Each floor type has specific properties which make it especially desirable or undesirable for particular shops.

Floors of packed down earth are used in certain storehouses, and in industrial areas where the floor is subjected to high temperatures, or where heavy objects falling might destroy other types of floors or the object itself (Osipov, p.358). They therefore appear in such buildings as forge shops, foundries, etc. Such floors usually have roadways for wheeled vehicles filled in with slag, rubble or gravel.

Adobe floors are used in sheds, garages or storage areas where the amount of dust created is not important; they have the advantage of being cheap, but are in need of frequent repair. Adobe floors may be made of a mixture of 15-30% clay and 70-85% sand, placed in two or three layers, 80-100 mm. thick and tightly packed or rolled at each layer.

For asphalt floors, Shtaerman (p.155) recommends a mixture of 50% granite or basalt, 22% quartz sand, 12% tripolite and 16% bitumen or asphalt. This, he claims, is proof against alkalis, salts and acids, but warns that such floors should not be used in areas where asphalt solvents, such as kerosene and alcohol are present. This flooring appears primarily in storage and other auxiliary departments, in passageways and for certain food-industry shops where acid-forming materials, such as certain animal and vegetable oils are prevalent.

Wood flooring is of two types, plank and block. Wood planking is fastened to sleepers which are imbedded in cement sub-flooring; wood block also rests on concrete or slag-concrete sub-flooring and the blocks are filled in with tar or sand. Wood flooring, according to Shtaerman has a low coefficient of heat absorption, resiliency, noiselessness, low wearability and is not dust-producing; it is also simple to repair and may have production equipment fastened to it. It is, however, relatively expensive and is recommended only where it is definitely needed.

Metal floors are made of iron or steel sheet. Because of the need to conserve metal, they are recommended only where other types of flooring are not possible, for example (Osipov, p.363), where the floor is subjected to heavy blows, or the activity of high temperatures through contact with red-hot objects, and other areas where the floor must have a smooth and hard surface. In high-temperature shops, they use cast-iron sheet measuring 250 X 250 or 300 X 300 mm. This is fastened to sub-flooring of sand or concrete, if sand, the layer is 80 mm. thick. For withstanding the weight of hard blows, steel plate is used, either stamped or sheet steel. This is laid on a cement base, which in turn is laid on concrete sub-flooring.

Cement and concrete flooring are widely used in production shops where the floor is subject to constant humidity or the action of mineral oils; in driveways for rubber-wheeled vehicles, and elsewhere. They also serve as the base for many other flooring materials.

In general, flooring cannot be classified by industry but differs according to the function of the area in the plant in which it appears. According to Shtaerman, in shops of the food industry where the floor may be subject to vegetable and animal oils and to sugar syrups, or foods prepared with these ingredients, floors must be made of metal plate, cinder brick or acid-proof asphalt. If metal or brick, these floors must be laid on acid-proof material. Indeed, if there is a possibility of leakage through the floor, he considers it undesirable to have reinforced concrete foundations, unless some water proof material is laid under the floor surface.

The classification in table 7 gives some indication of floor variety and area of use, particularly in construction industry plants.

Table 7

Flooring Types in Construction Industry and Other Shops

<table>
<tr><th>TYPE OF FLOOR</th><th>(1)
Concrete & Mortar Plant</th><th>(2)
Slag-Concrete Masonry Plant</th><th>(3)
Reinforced Concrete Products Plant</th><th>(4)
Clay-Brick Products Plant</th><th>(5)
Wood-working Factory</th></tr>
<tr><td><u>WOOD</u>
A. Board or Plank</td><td colspan="4">Locker rooms and offices</td><td>Second floor of saw-mill; machine storage and assembly; depts. of furniture and carpentry shop</td></tr>
<tr><td>B. Block (parquet type)</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td><u>CONCRETE</u></td><td></td><td></td><td></td><td>Display rooms</td><td>Storage areas</td></tr>
<tr><td><u>CEMENT</u></td><td>All production depts. of mixing shop</td><td>Proportioning and molding depts.</td><td>Molding, cooling and polishing depts.</td><td>Pressing dept</td><td>Painting shop</td></tr>
<tr><td><u>ASPHALT</u></td><td>Unloading plat-form in cement storage</td><td colspan="2">Passageway for loaders; finished product storage</td><td></td><td></td></tr>
<tr><td><u>PLATE METAL</u></td><td colspan="5">Health stations</td></tr>
<tr><td><u>MOSAIC TILE</u></td><td colspan="5">Cage of Stairway</td></tr>
<tr><td><u>CINDER BRICK</u></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td><u>BRICK</u></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 7 (Cont'd)

Flooring Types in Construction Industry and Other Shops

TYPE OF FLOOR	(6) Construction Industry: Machine and Repair shops	(6) Construction Industry: Garages	(6) Construction Industry: Material storage	(7) Refrigerator semi-temporary	(8) Sugar Refining	(9) Fruit Cannery	(10) Soap-making shop
WOOD							
A. Board or Plank	--------Locker rooms & offices						
B. Block (parquet type)	Machine and tool shops						
CONCRETE	Fitting and assembly dept.; boiler and welding rooms	Apparatus dept.					Ore prod. Shop floor (over cement layer)
CEMENT	Auto-engine repair shop; Boiling; Acetylene; metal plating	Washing & inspection stations; painting shop					
ASPHALT		Auto parking; compressors; Tackle; Tire-repair dept; Electro-carburetor dept.	Storage areas; loading & unloading platforms	Main floor (on slag concrete base)		Production floors	
PLATE METAL	Health stations	Health stations accumulors	Health station				
MOSAIC TILE	-----------Cage of stairway----------------						
CINDER BRICK	Forging and heating dept.						
BRICK	- -						← Ground floor of multi-story section; and other sections

6. Roofs

These may be divided into three elements: roofing material; i.e., that part which meets the elements; roof deck, on which the roofing material is placed; roof beams and supports through which the weight of the roof is carried to the skeletal supports. Except for a few multi-story buildings, industrial buildings have no lofts or attics.

Roof beams or supports may be of wood, structural steel or reinforced concrete (according to Osipov). Wood is rarely used because of fire hazard, structural steel is widespread in the USSR, but because of its costliness, is preferably replaced by reinforced concrete beams, precast. Standard sizes of such beams, when made of precast reinforced concrete are 6, 9, 12, 15, 18 and 24 meters in length, with height equal to one-fourth of length. Beams over 12 meters are made in individual 3-meter sections. For multi-wing buildings with bays from 60 to 90 meters, it is preferable to use arched supports. Such arches of brick are considered very economical (see figure 12). Cylindrical arch shells are considered sturdy (see figure 13). They are usually of reinforced concrete 80-100 mm. thick. However, they may also be of multi-layered wood, in thin flexible boards placed in layers at angles to each other. At present, a new reinforced concrete arch is favored (see figure 14). The concrete is 40-50 mm thick and has a span of 20 to 25 meters. The expenditure of metal for such structures is 2.5 times less than for comparable structures.

According to Osipov, roof decks of industrial buildings are most frequently made of reinforced concrete, asbestocement and wood. In monolithic reinforced concrete deck, the concrete sheets are attached to the purlins; with precast sheets, it is more economical to eliminate purlins (progony).
Most modern development is the use of autoclavic porous concrete for roof

decks, which serves as insulation as well. Standardized sheets of such material are 1.5 and 3 meters long; o.5 meters wide; and 0.14 to 0.16 meters thick. Such materials can be used only over areas with normal interior humidity. In general, however, the most usual procedure is to use other insulating materials under the exterior roofing.

Roofing materials are extremely varied, and may come in sheets, blocks or rolls. According to Shtaerman, the most frequently used sheet material in the food industry is roofing iron, which comes in sheets 1420 by 710 mm. and weighs from 3.25 to 6 kg. Frequently corrugated iron is used in sheets from 3 to 6 meters long, 0.4 to 0.9 meters wide and 1-1.5 mm. thick. Another sheet roofing is made of Portland cement and asbestos fiber (called Asbofanera in Russian). These vary in dimensions from 60 X 120 cm. to 100 X 200 cm. and are from 4 to 12 mm. thick. This is a highly fireproof material.

The block types are various forms of fired-clay tile, slate, and shingle. The most common form of rolled roofing material is ruberoid, which is a pressboard impregnated with bitumen. It comes on rolls 0.8 and 1 meter wide and 20-25 meters long. There are also other types of pressboard rolls.

In general, medium and light industry buildings must be heated and require roof insulation. According to Belenia, this adds significant weight to the roof, and the roofing material should therefore be light weight. He suggests that in zones where snow on roofs reaches a weight of 100-150 kg/m^2, the roofing material should weigh no more than 70-100 kg/m^2 ; where the snow load is 50-80 kg/m^2, the roofing material may weigh as much as 150 kg/m^2.

In heavy industry, plants are frequently unheated, and the technological processes produce heat. Here the roofs need not be insulated and are usually, according to Belenia, of corrugated iron or steel, or asbestos cement.

Figures 12 and 13

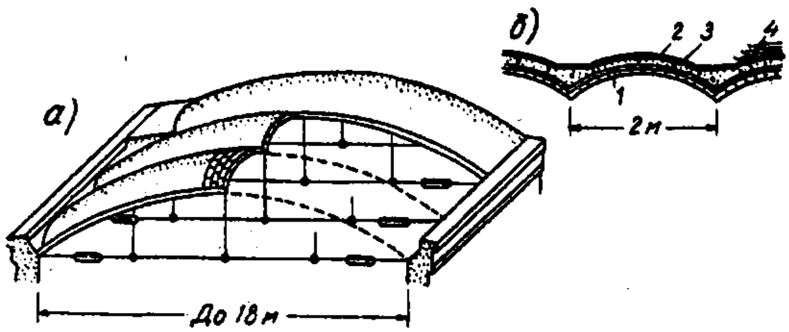

Рис. 273. Кирпичные своды двоякой кривизны
а — общий вид; б — деталь свода; 1 — кирпичный свод; 2 — утеплитель; 3 — стяжка; 4 — кровля

Figure 12. Brick dome with double arches

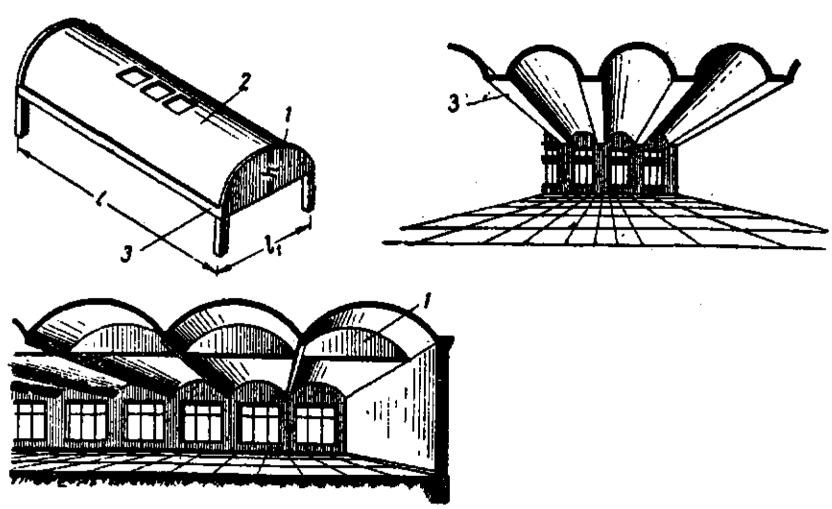

Рис. 274. Железобетонные цилиндрические оболочки

Figure 13. Reinforced concrete cylindrical domes

Source: Osipov, p.332

Figure 14.

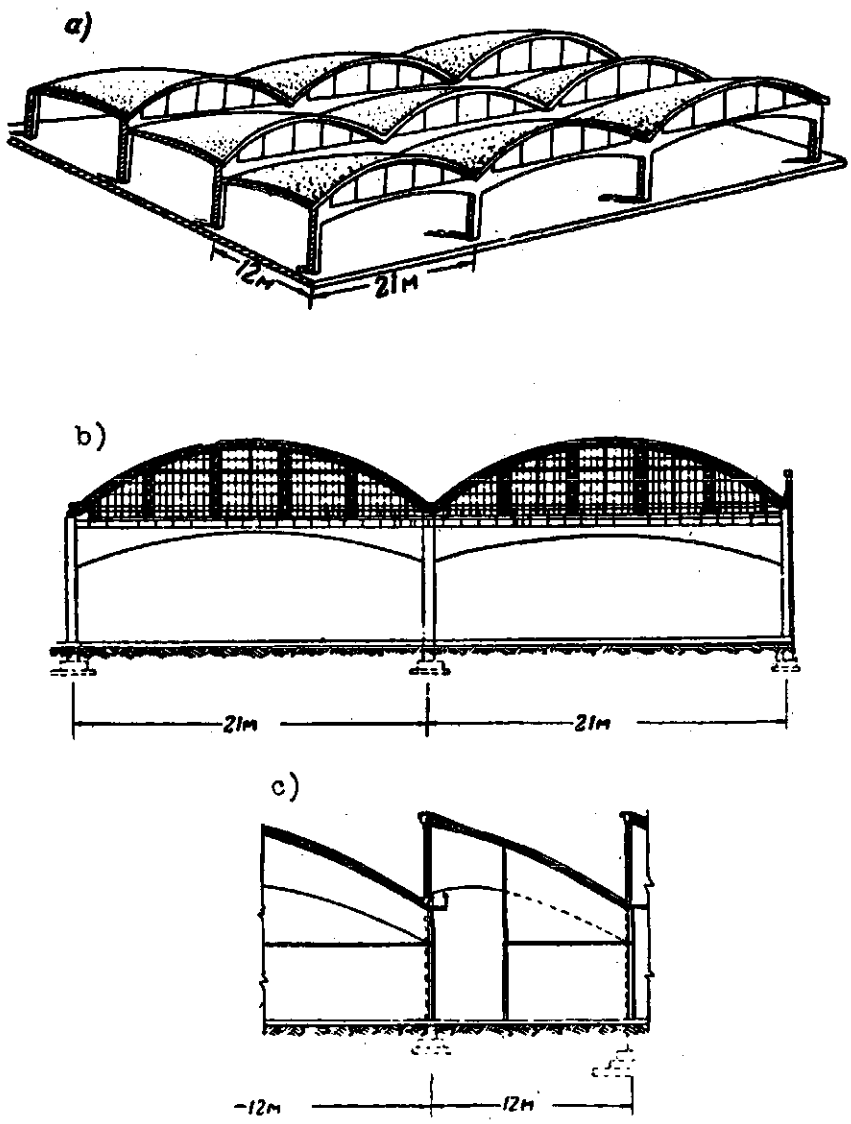

Рис. 275. Тонкостенные своды-оболочки двоякой кривизны

а — общий вид; *б* — продольный разрез; *в* — поперечный разрез

Figure 14. Thin-walled Double-arched Domes

(a) General view

(b) Lengthwise view

(c) Side view

Source: Osipov, p.334

7. Air and Lighting Facilities

In general, industrial buildings are constructed to use daylight, although, according to Belenia, for 10 years they have been designing buildings with artificial light to overcome lack of even light and poor weather conditions. Two types of apertures are in use: wall windows and overhead skylights. According to Belenia, buildings with only one wing and with height of working area to width not less than a ratio of 1 to 2, light may be introduced through wall windows. According to Osipov, the frames of such windows are made of wood, steel or reinforced concrete. Skylights may be used only for light, or as a means of ventilation or for both. Those used for light alone, have glass set in at a 45° angle, but cannot be opened. Skylights are of various shape, depending on their purpose. Rectangular skylights are particularly common, and especially good in tropical regions because they let in less sunlight than other shapes. M-shaped skylights are used mostly for shops which have heat-producing technologies because the angle of the glass allows better ventilation. Belenia suggests that for industrial buildings of standard design, the best procedure is to use artificial lighting and ventilation, so that the building design need not be affected by these factors.

Figure 15.

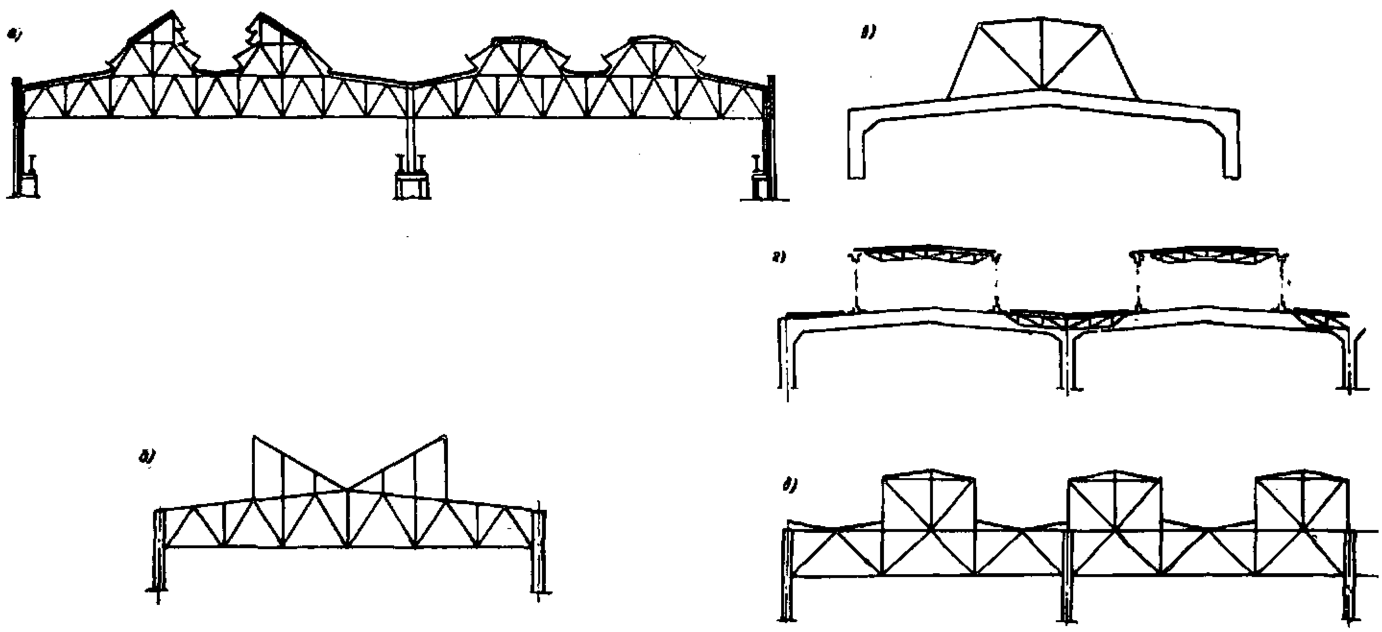

Рис. 16. Схемы покрытий с продольными фонарями

Figure 15. Skylight types

Source: Belenia, p.30.

8. Other Elements

Several very important elements have been omitted from this study, due to lack of time and insufficient material. These include doors, stairwells, elevator shafts, and such unformed , but labor and material consuming elements as plastering and surface facing. These last two are more important in nonindustrial buildings. Indeed, plastering appears to take from 15 to 25% of the manhours in construction of housing (see Syrtsova). Other, less significant, elements omitted include roof and foundation insulating materials and sub-foundation sands and gravel fill.

Figure 16

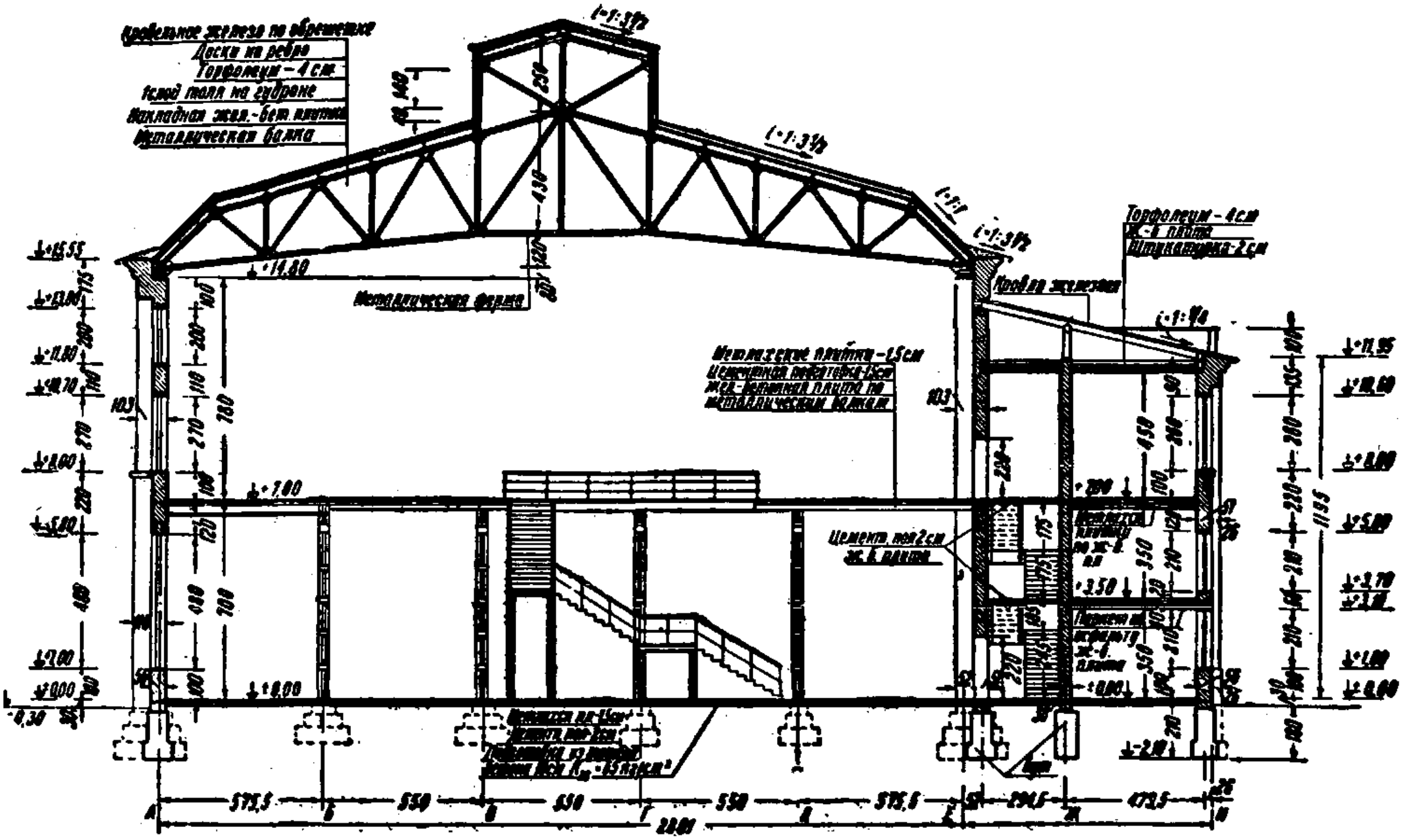

Рис. 228. Разрез через главный корпус сахарного завода.

Figure 16. Sugar Refinery

Source: Shtaerman, p. 250

Figure 17.

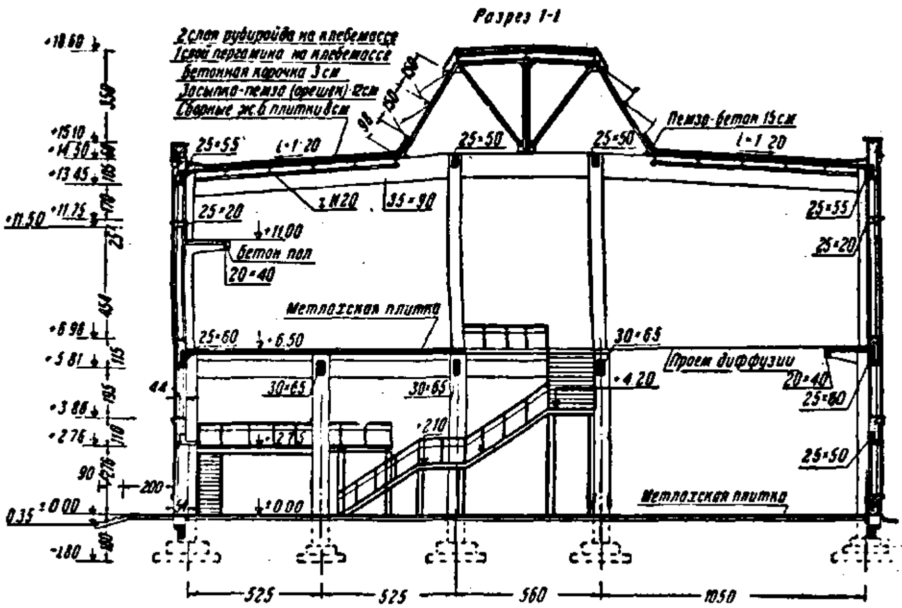

Рис. 230. Разрез через главный корпус сахарного завода.

Figure 17. Sugar Refinery

Source: Shtaerman, p.252

Figure 18

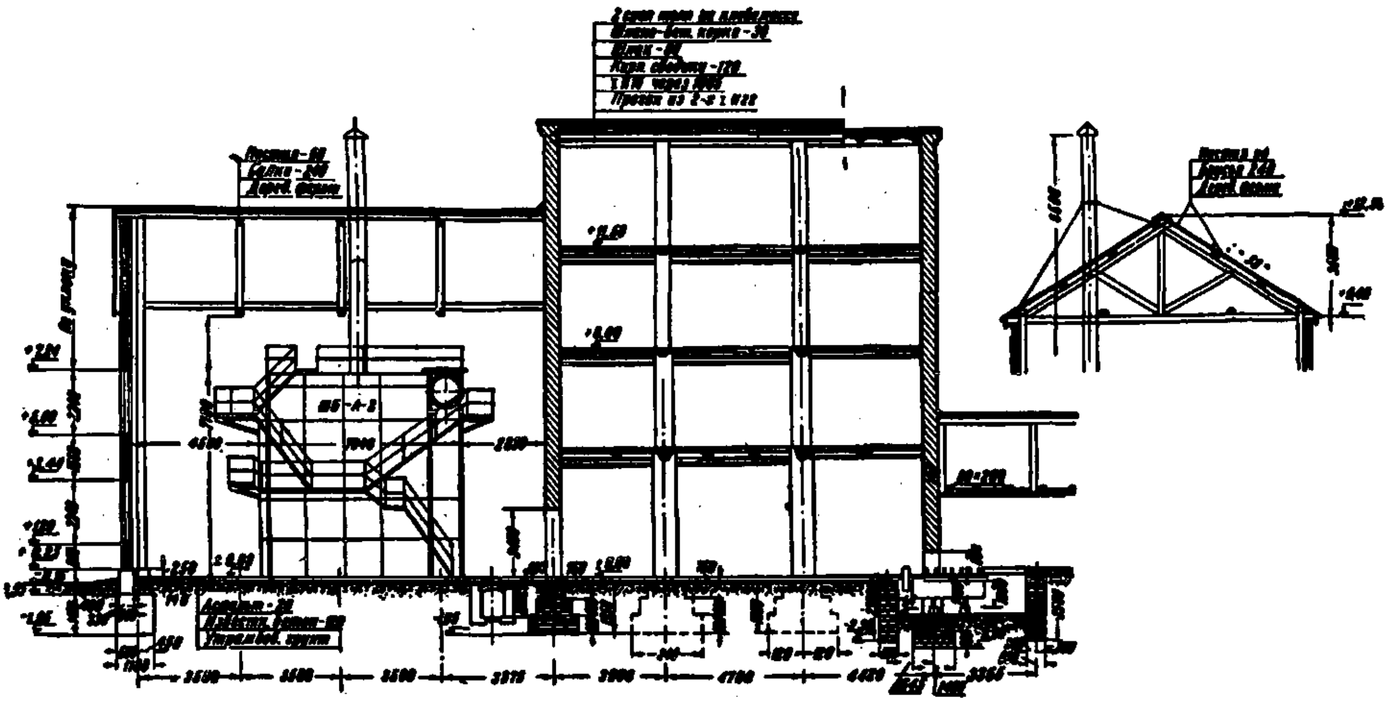

Рис. 233. Разрез через главный корпус спиртзавода.

Figure 18. Alcohol Factory

Source: Shtaerman, p.254.

Figure 19

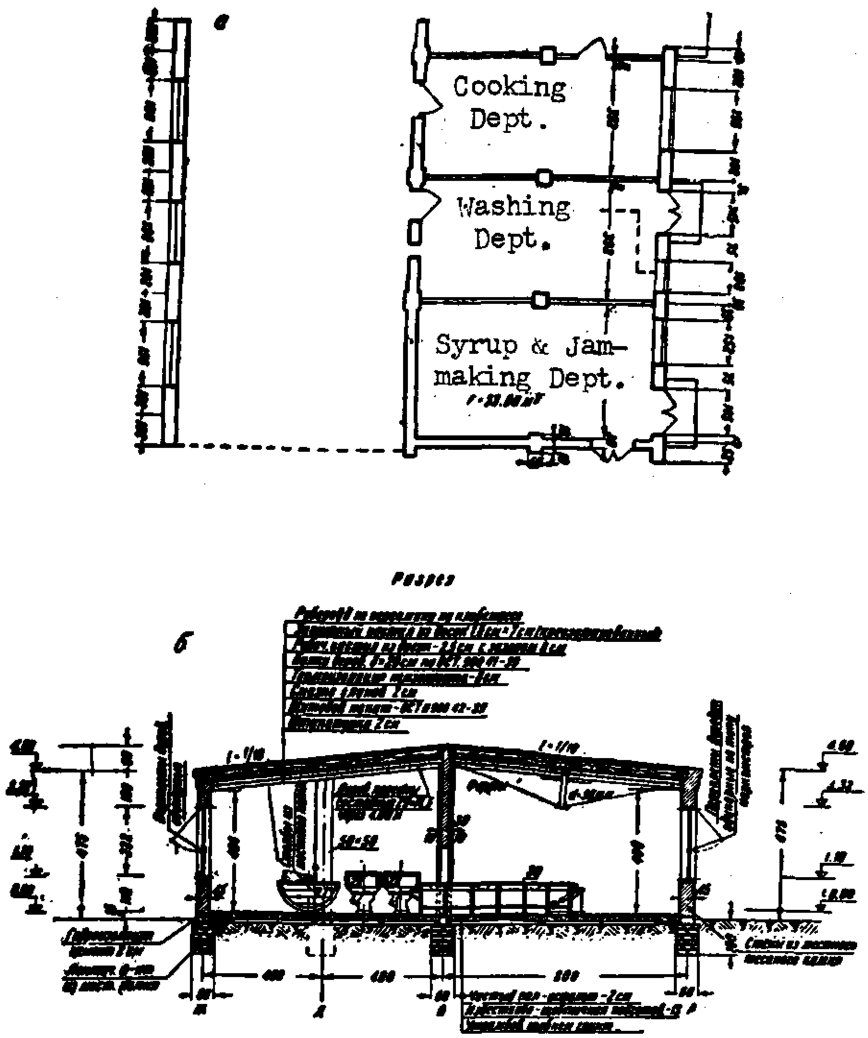

Рис. 238. Фруктово-консервный завод.

а — часть плана; б — часть разреза

Figure 19.. .Fruit.Cannery

Source: Shtaerman, p.259

Figure 20.

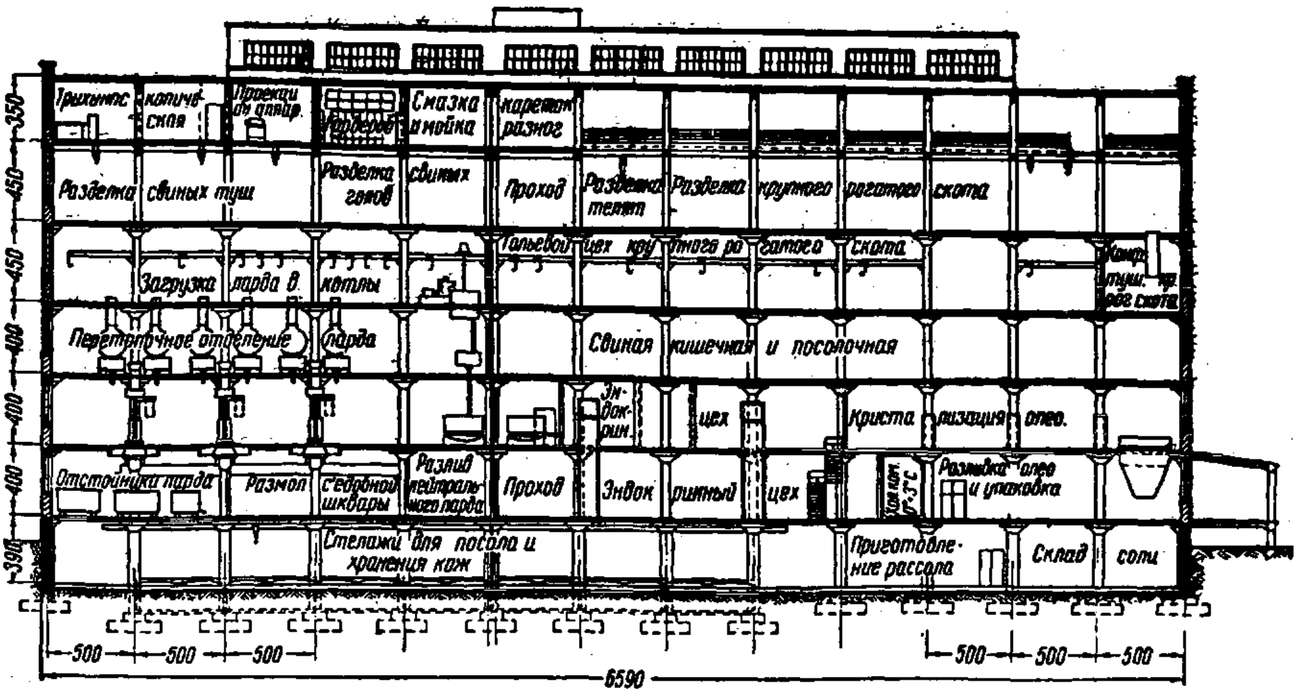

Рис. 234. Продольный разрез убойно-разделочного корпуса мясокомбината.

Figure 20. Meat Dismembering Department of Meat Kombinat

Source: Shtaerman, p.255

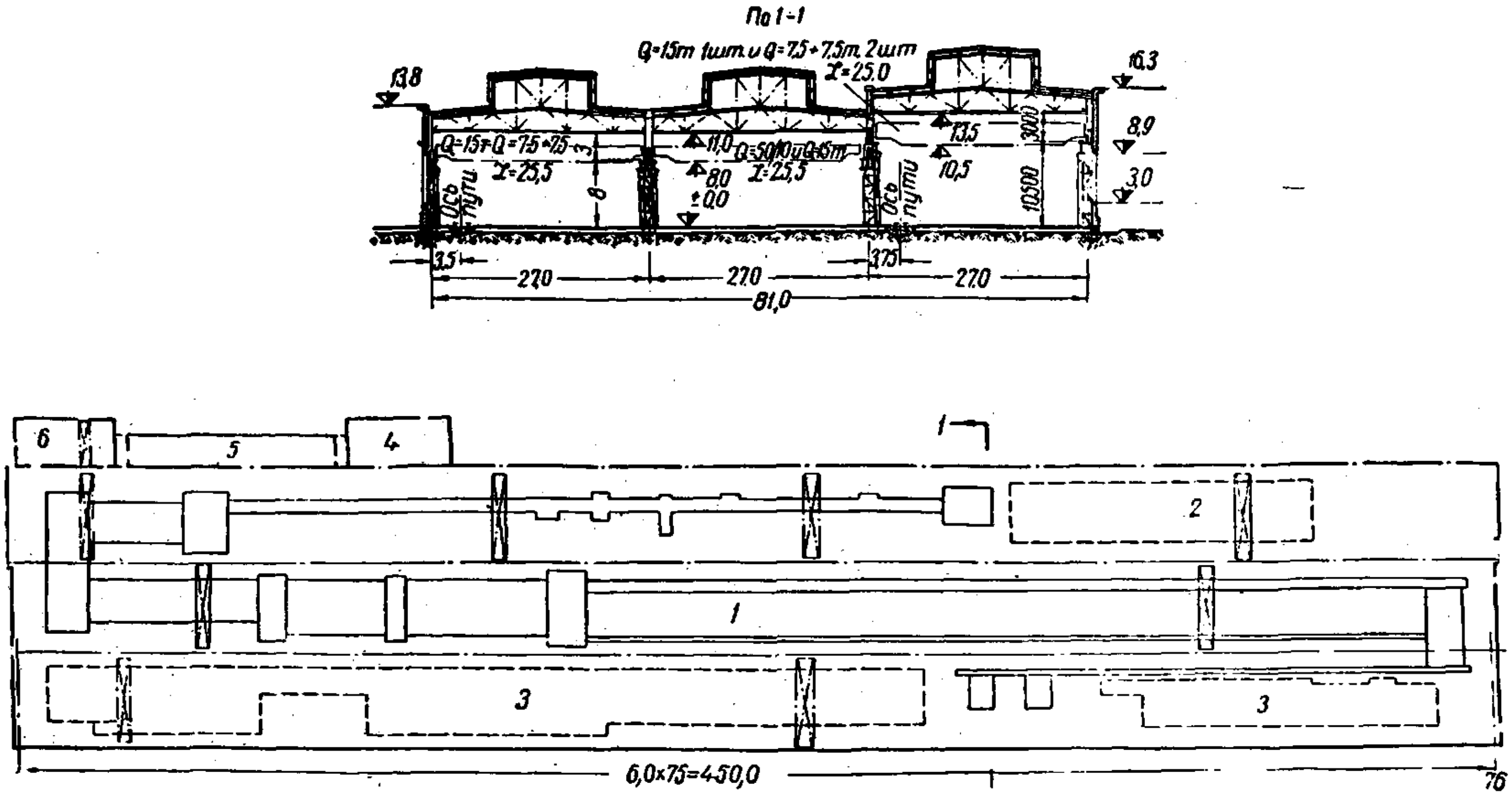

Рис. 86. Трубоэлектросварочный цех Челябинского трубопрокатного завода

1 — цех; 2 — склад листа; 3 — склад готовых труб; 4 — насосно-акку... нция; 5 — бытовые помещения; 6 — склад флюса

Figure 21. Shop for Electric Welding of Pipe, Chelijabinsk Pipe Rolling Plant

Source: Pokazatelnoe Strojitelstro

Figure 21.

Figure 22.

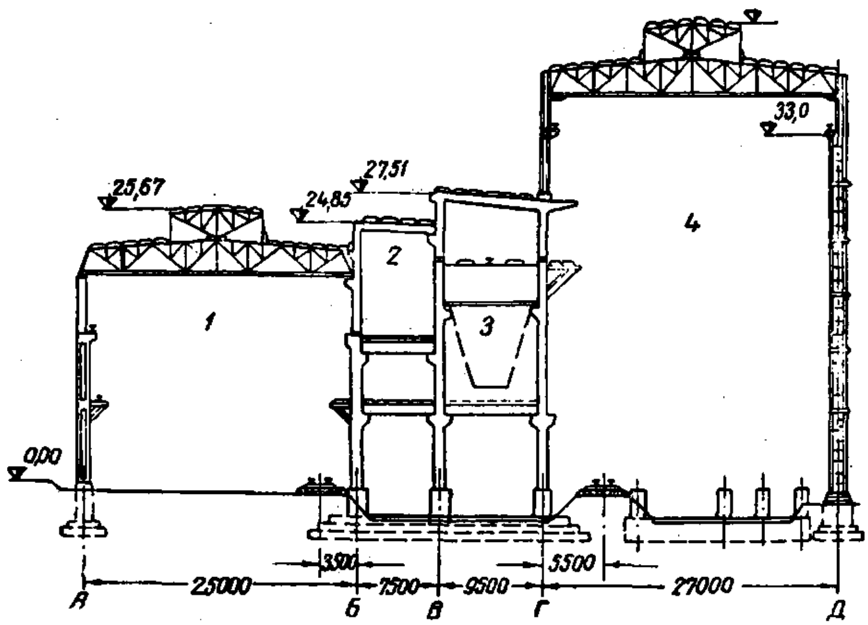

Рис. 135. Поперечный разрез главного корпуса Кировской ТЭЦ в Ленинграде

1 — машинный зал; 2 — деаэраторное отделение; 3 — бункерное отделение; 4 — котельный зал

Figure 22. Main Shop of Kirov Thermo-Electric Power Plant in Leningrad

Source: Pokazatel'noe Stroitel'sno, p.168

APPENDIX

TABLE A.

STRUCTURAL ELEMENTS IN SELECTED CONSTRUCTION INDUSTRY BUILDINGS

	Plant Shop or Installation	(1) Output (Type and capacity)	(2) No. of Workers	(3) Main shop floorspace (m^2)	(4) Shop volume (m^3)	(5) No. of Stories	(6) No. of Bays	(7) Width and Height of Bays	(8) Foundation	(9) Skeleton	(10) Walls	(11) Cranes	(12) Columns	(13) Roof	(14) Other	
1	Crushing and sorting plant	250,000 m^3 of quarry stone and gravel	49		7,400					Reinforced Concrete						1
2	Crushing and sorting installation	30,000 m^3 of stone	8		485					Wood	Wood sheathed					2
3	Water chlorination installation	$9m^3$ per shift	4	29.7	308					Wood	Wood					3
4	Concrete and Mortar shops	41,000-113,000m^3 cement ; 30,000-60,000m^2 of mortar	14-43	144-290	3,132 -6,891	multi	1			Reinforced concrete	Filled brick			Reinforced concrete sheet		4
5	Concrete and Mortar shop	100,000m^3 concrete 40,000 m^3 mortar	65							Reinforced concrete	Cinder block					5
6	Temporary concrete-making shop	243,000m^3 concrete	15	80	2,715					Metal, temporary	Wood panels heat instal-lations					6
7	Reinforced concrete products shops	10,000-15,000m^3	76-200	2,215-4,342	19,141 -21,893						Brick					7
8	Reinforced concrete products shop (Large panels for dwellings)	10,000m^3	131	5,058	25,600					Reinforced concrete	Brick					8
9	Reinforced concrete products shop	5,000m^3	57	1,170	8,205					Reinforced concrete	Brick					9
10	Reinforced and "cellular" Concrete Shop	20,000 m^3	80	4,036	40,408					Metallic	Cinder block					10
11	Plant for reinforced (armored) Foamy cement and foamy silicates (main shop)	12,000 m^3	68	2,358	10,728					Reinforced concrete	Brick					11
12	Fittings shops	5,000-7,500 tons	59-77	792-1,224	3,800-6,074						Brick or cinder block					12
13	Shop for: plaster board panels or structural parts	3,000-7,500 m^3	47	600	2,710 (incl. shop and open shed)					Wood	Wood fill and brick					13
14	Shop for plaster-slag elements	7,500 m^3	65	910	3,980					Bricks	Bricks					14
15	Sawmill	98,000-134,000m^3	70-166	680-3,320	5,300 -17,371	1 or	1				Bricks					15
16	Sawmill	12,000	26	400	2,257	2				Wood				Wood		16
17	Forging-welding shops	–	18	483	2,186					Wood	Brick			Wood		17
18	Mechanized cement storage	3,500 tons	5	500	6,700										Wooden silos	18
19	Mechanized cement storage	2,000 tons	7	690	4,030					Reinforced concrete	Filled concrete				Wooden silos	19
20	Material storage (with shed)			1228	4,679						Cinder block					20
21	Main warehouse and metal storage			504	1,881					Wood	Wood					21
22	Garage (to service 400 trucks with heated park for 94 autos)		500	7,981	42,000					Metal with brick fill						22
23	Garage for 100 trucks		85	1,500	7,300					Brick	Brick					23
24	Truck overhaul shop		188	3,370	17,500					Brick	Brick					24
25	Furniture and wood parts shop (incl. wood-drying room combined with finished product storage)					1	2				Brick, cinder block or cinder. Wooded regions, wood.	Girder crane in storage room		Wood	Drying kiln of calcined clay brick	25
26	Clay-brick plant										Brick			Reinforced concrete (precast) over main production shops-the rest is wood.		26
27	[illegible]										Brick or cinder block			wood and reinf. a/		27

TABLE A (Cont'd)

STRUCTURAL ELEMENTS IN SELECTED FOOD INDUSTRY BUILDINGS

	Plant Shop or Installation	(1) Output (Type and capacity)	(2) No. of Workers	(3) Main shop floorspace	(4) Shop volume	(5) No. of Stories	(6) No. of Bays	(7) Width and Height of Bays	(8) Foundation	(9) Skeleton	(10) Walls	(11) Cranes	(12) Columns	(13) Roof	(14) Other
1.	Sugar refinery (fig.16)			(see fig.16)		2-3			Rubble stone	Steel	Brick		Steel	Roofing iron, wooden sheathing, reinforced concrete base sheets	Floor between stories is reinforced concrete slab on sheet beams
2.	Sugar refinery (fig.17)			(see fig.17)		2				Reinforced concrete	Reinforced concrete filled with tuff			Ruberoid on cement; on reinforced concrete base sheets	Flooring appears to be metal sheets
3.	Alcohol factory (fig.18) (1945 model)														
	Left part:					1			Brick	Wood	Brick		Wood	Wood	
	Right part:			(see fig.18)		4				Structural steel			Brick	Structural steel and brick	
4.	Fruit Cannery (in South)					1	3	(see fig. 19)	Local stone		Locally cut stone		Local stone	Wood covered with ruberoid	
5.	Soap-making shop of oil and fats factory														
	Left part:					3					Brick		Wood for top floor. Brick arch covered with cement sheets and ruberoid	Roof iron on wood lathing.	Two arches in roofs of different heights
	Right part:					1									
6.	Meat-dismembering Dept. of meat-kombinat			30 meters wide	See fig. 20	7									
7.	Refrigeration Plant (semi-temporary)					1			Quarry stone	Wood	Brick (38 c.m. thick)		Wood	Wood	

STRUCTURAL ELEMENTS IN OTHER INDUSTRY BUILDINGS

	Plant Shop or Installation	(1) Output (Type and capacity)	(2) No. of Workers	(3) Main shop floorspace	(4) Shop volume	(5) No. of Stories	(6) No. of Bays	(7) Width and Height of Bays	(8) Foundation	(9) Skeleton	(10) Walls	(11) Cranes	(12) Columns	(13) Roof	(14) Other
1.	Blast furnace shops*				1386m^3				Precast reinforced concrete b/						
2.	Four-story industrial buildings* (industry unknown)			1,800 m^2	37,000m^3				Monolithic reinforced concrete	Precast reinforced concrete	Brick (basement walls monolithic concrete)		Precast reinforced concrete		
3.	Plant for industrial rubber products*			8,800 m^2 (Dimensions 30 x 129m)	66,800m^3	2			Monolithic precast reinforced concrete (basement)	Reinforced concrete (precast)	Large brick blocks		Reinforced concrete (precast)	Panels 6x1.5m. of reinforced concrete	Steel beams under 2nd floor reinforced concrete flooring
4.	Electric pipe-welding shop*	Produces welded pipe with diam. of 720 mm.		37,900	650,000 (see fig. 21)	1	3	Each 27 m. in width (see fig. 86)	Monolithic reinforced concrete	Structural steel	Brick (slag block along metal frames)		Structural steel	Precast reinforced concrete with ruberoid covering	
5.	Thermal-electric power plant* 1. Figure 22 c/			6,790 (plot of land on which bldgs. stand)	204,650	1	4	d/		Reinforced Concrete and structural steel	Reinforced foamy cement panels (replaces brick masonry)		Reinforced concrete and structural steel	Large reinforced concrete panels	Between story flooring like roof
	2.			13,624 (plot of land, etc.)	442,400	1-3	4	d/		Structural steel	Reinforced foamy cement panels (replaces brick masonry)		Steel		

a/ The roofs of forging and welding departments, and roof of shop for repair of internal combustion engines are reinforced concrete, the rest is wood.

b/ Under foundation was a slag layer 2.5 meters thick and a slag-cement layer 1.5 meters thick; the total volume of the sub-foundation layer was 9,800 m^3.

c/ The width and height of Bays differ according to department as follows:

		Department			
		Machine Hall	Deaeration Dept.	Bunker Dept.	Boiler room
Plant #1	Width of Bay(Meters)	25	7.5	9.5	27
	Height of Bay (M.)	21	25.6	28.35	38
Plant #2	Width of Bay (M.)	24	7.5	9.5	27
	Height of Bay (M.)	23	25.6	28.35	40

See Fig. 22

d/ Connected foundation plate of bunker and deaeration depts., columns in face of machine hall are precast reinforced concrete. Column in face of boiler room, girders and roof beams of machine and boiler rooms and other parts are of metal.

* These are all of model type with more precast reinforced concrete than usual. They represent the most advanced standards in terms of high mechanization of construction and labor and material saving design.

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