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Steel Structures for Mass Construction in the USSR

Utilisation de structures en acier pour des constructions en masse en URSS

Stahlkonstruktionen für die Massenverwendung im Bauwesen der Sowjetunion

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The problems of mass industrial construction in the U.S.S.R. arised in 1929 in connection with realization of tasks in the I-st Five - Year Plan of national economy development.

A sudden jump in rates and volumes of the capital construction was possible only in industrialization conditions. New principles and methods for designing and fabrication, adequate to the tasks, were required instead of designing with the use of unlimited variety of both volumetric-planning and structural solutions of steel structures and semi-homemade piecework production of them.

The regulation of structural parameters for buildings of the machinery industry with a simultaneous unification of crane facilities, carried out in 1933 was an important event with respect to mass construction regulation.

Extremely short terms taken for designing during the period of rapid development of national economy have brought to the fact, that the best projects of steel structures have been repeatedly used and then have been approved as standard projects.

Subsequently the transition was accomplished from standardization of simple auxiliary buildings and installations (garages, storages, boiler houses, fire stations, etc.) to development of standardized units of principal production.

The standard projects for buildings of oil-refining, machine-constructing, coal industry and other branches of national economy have been worked out by different design offices by the middle of the thirties.

The standard sections of single-storey industrial buildings, approved in 1939 and then being improved more than once have been of great importance in the process of steel structure standardization.

They are of interest in relation to highly consistent (for that time) conducting of principles of structural parameter unification.

Thus, in standard sections, column spacing and also vertical dimensions of buildings up to level of crane rail and bottom of roof carrying structures were unified.

Together with standardization of buildings of fixed technological purpose and development of mobile sections providing for arrangement of different industries, at the same period it was undertaken an elaboration of standard members, including the most frequently used steel members of the building framework, namely, crane girders, monitors for lighting and aeration and roof trusses.

In some cases all-union standards for individual installations and structural members of mass use were developed, for example, standards for steel window and monitor sashes of industrial buildings, fuel tanks, gas-holders, etc.

It can be seen, that the transition from individual designing for separate building and installation to standard structures was started from obtaining and fixation of the most generally used spacing, bays and heights. On the basis of them standard projects of buildings for a virtual technological process were developed and subsequently the transition was accomplished to standard sections of universal use allowing to obtain and develop individual standard structures designed to be used in the buildings of different purpose.

An introducing of all-state unified modular system ("EMC") pointing out a procedure for direction and coordination of volume, planning and structural parameters of buildings and installations in residential, civil, agricultural and industrial construction contributed to realize standardization works.

It shall be noted, that designers have hardly managed to solve the encountered problems at the beginning of intensified construction in the country and their principal trains were directed to simplification in designing and reduction of terms for project execution, but as time proceeds and in the course of industrial base development they began to give great attention to a production aspect of standardization.

And at present the standard superstructures of railway bridges worked out in the fourties may serve as the example of successfull conducting of modular system principles and subjecting structural form to tasks of the jig method introduction in manufacture of members.

A critical consideration of state of single-storey industrial buildings from the point of industrialization in manufacture of them, carried out in the fifties, showed, that elaboration of standard projects on the basis of unified modular system ("EMC") and virtual technological requirements had nevertheless brought to an unacceptable variety of building types and an increase in number of standard sizes of structural members.

A great analytic work of designers together with profes-

sional technological enterprizes was required in the field of further unification of structural parameters, at first within the limits of separate branches and subsequently also on inter-branch unification in the course of which a system of enlarged modules was developed and nomenclature of framework members the most widely used, was revealed.

It shall be noted, that the development of industrial production of precast reinforced concrete structures for residential and industrial construction was a stimulus of a sharp reduction in a number of standard sizes for structural members.

The process of finding methods for reduction in a number of members being distinguished, the most expedient from the point of the whole national economy, was accompanied by establishing of methods of technical and economical studies of efficiency of digram and dimension unification and also structure standardization and contributed to a successfull development of standard designing not only in reinforced concrete structures but also in metal structures.

Purposeful activities of engineers and architects for many years in the field of standardization and unification in a constructional designing resulted in obtaining a modern type of industrial building characterized by simplicity of diagram and volumetric solution, clearness of divisions and the minimum set of industrial production members.

The sets of standard members for the structures made of different materials including steel began to be worked out in conformity with unified gabarite diagrams for buildings of branch and inter-branch purpose, the most widely used.

In 1962 in Cniiproectstalconstructsia a catalogue was issued intended for standard steel structures for industrial construction in which all standard structures of single-storey industrial buildings worked out during the period of 1954 to 1962 were unified.

The structures and products which formed the catalogue were intended for an obligatory application by all design and construction enterprises of the country and permitted to complete entirely buildings of different purpose with unified structural parameters, designed both in a steel and combined framework.

The optimum conditions of the catalogue standard structures were secured by a high skill of executors, choise of the best solution from a great number of variants taking into account complex criteria of steel cost, expenditure and labour-consuming character in manufacture and erection.

The catalogue structures covered buildings with bays equal to 24, 30 and 36 m, provided with cranes of load carrying capacity up to 75 tons in case of height up to 18 m; the load on the roof was provided from 250 to 750 kg/m^2 (column spacing equal to 6 and 12 m was permitted).

The catalogue gave the designer an opportunity to compose industrial buildings of set of economical structures of roof trusses, columns, crane girders, trusses and monitors for lighting and aeration, carefully worked out.

At the same time the catalogue contained too many standard

sizes, although the structures for regions with low temperatures and increased seismic load were not presented in it. (See table 1 for standard sizes of roof trusses)

T a b l e I

Number of shipping members for standard roof trusses

Span m	Steel class	1962										1971				1972
		Slabs 1,5 x 6m	Slabs 3 x 6m	Slabs 3 x 12m	Additional shipping members for suspended transport: Slabs 1,5x6 m	Additional shipping members for suspended transport: Slabs 3x6m	Summary	Coefficient of increasing members acc.to different slopes of roof	Coefficient of increasing members acc.to adjustments of wall (0 and 250mm)	Coefficient of increasing members acc.to different temperatures of service	Summary taking into account coefficients	Slabs 3 x 6 m and 3 x 12 m	Coefficient of increasing members acc.to adjustments of wall (0 and 250 mm)	Coefficient of increasing members acc. to different temperatures of service	Summary taking into account coefficients	Slabs 3x6m and 3x12m
18	C24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	C35+C24	6	11	-	9	6	32	2	2	2	384	10	3	2	60	10
24	C24	6	6	7	-	-	19	2	2	2	152	-	-	-	-	-
	C35+C24	6	5	6	13	11	41	2	2	2	328	9	2	2	36	9
30	C24	7	7	8	-	-	22	2	2	2	176	-	-	-	-	-
	C35+C24	7	6	8	16	13	50	2	2	2	400	9	2	2	36	9
36	C24	7	8	8	-	-	23	2	2	2	184	-	-	-	-	-
	C35+C24	7	7	7	15	12	48	2	2	2	384	9	2	2	36	9
Total:											2008				168	37

Subsequently a number of standard sizes was essentially reduced as a result of refusal from excessive variance of diagrams and steel grades being used, increase of load gradations and refusal from rare parameters and inner unification.

Simultaneously detailed drawings for standard steel structures, common for all plants, were elaborated according to the proposals of the enterprises making steel structures. So, the industrial direction of standardization has obtained a further development.

And at present the standard structures as well as nomenclature and some standard sizes of them are in progress. Every year the studies of standard structure application are carried out in design offices, at the plants for structural steelworks and in the field; shortcomings are revealed and eliminated.

The research and experimental studies are realized which are intended for working out perspective standard structures and new technological procedures for a specialized production of them.

In our country the use of standard steel structures grows from year to year. A relative increase of volumes in manufacture of standard steel structures for industrial buildings for the

last five years is shown in table 2.

T a b l e 2

Use of standard structures in per cent

/Total weight of structures of the given type is accepted as 100%/

Structure description \ Years	1966	1967	1968	1969
Roof trusses	43,0	45,0	48,0	52,0
Crane girders	32,0	29,0	34,0	57,0
Monitors /lighting and aeration/	77,0	80,0	91,0	97,0
S a s h e s	100,0	97,0	100,0	100,0
Stairs, platforms and railing	16,0	17,0	33,0	27,0

The results of the study carried out in relation to the problem of using roof trusses and crane girders in terms of loads and bays are given in figures 1, 2, 3 and 4.

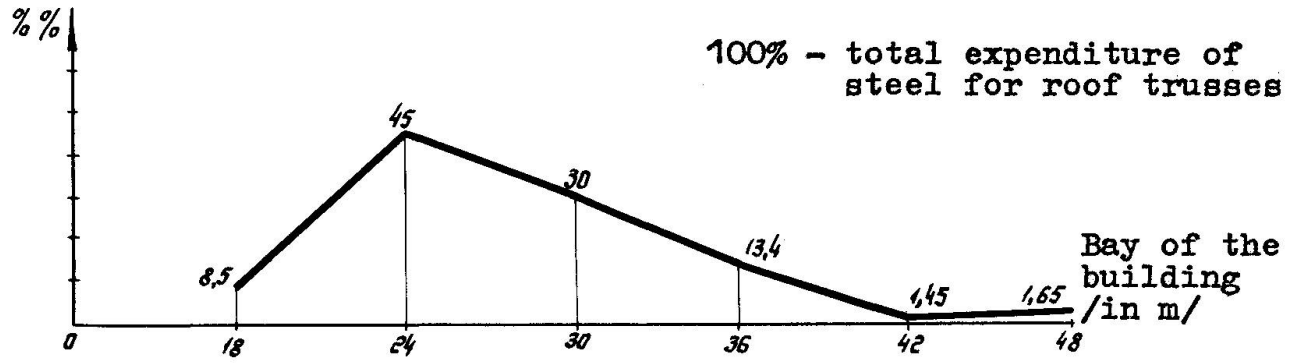


Fig. 1. Use of roof trusses in per cent in terms of the building bay

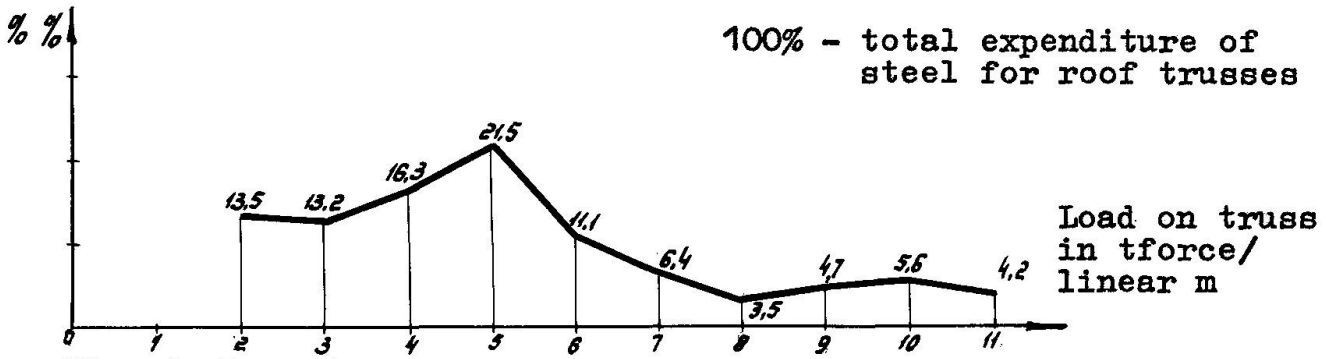


Fig. 2. Use of roof trusses in per cent in terms of load effected on the truss

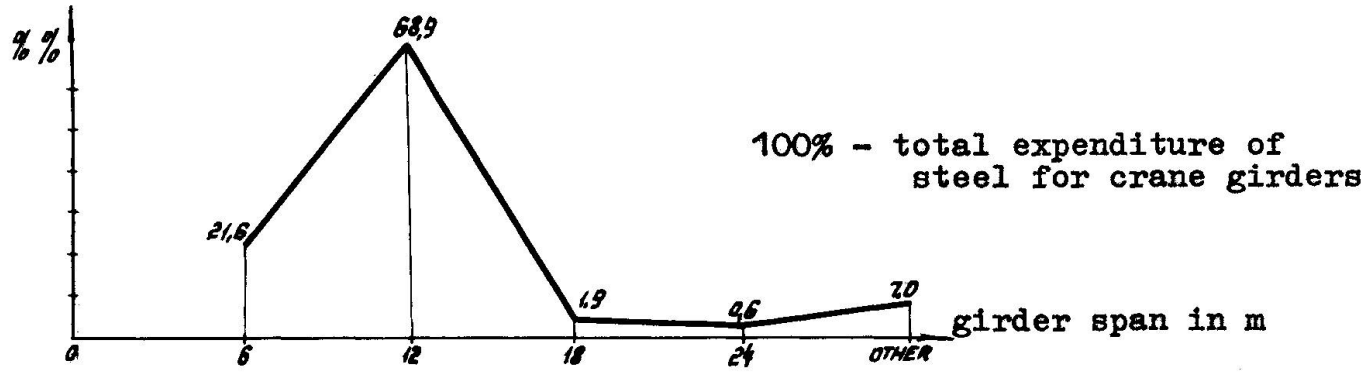


Fig.3. Use of crane girders in per cent in terms of girder span

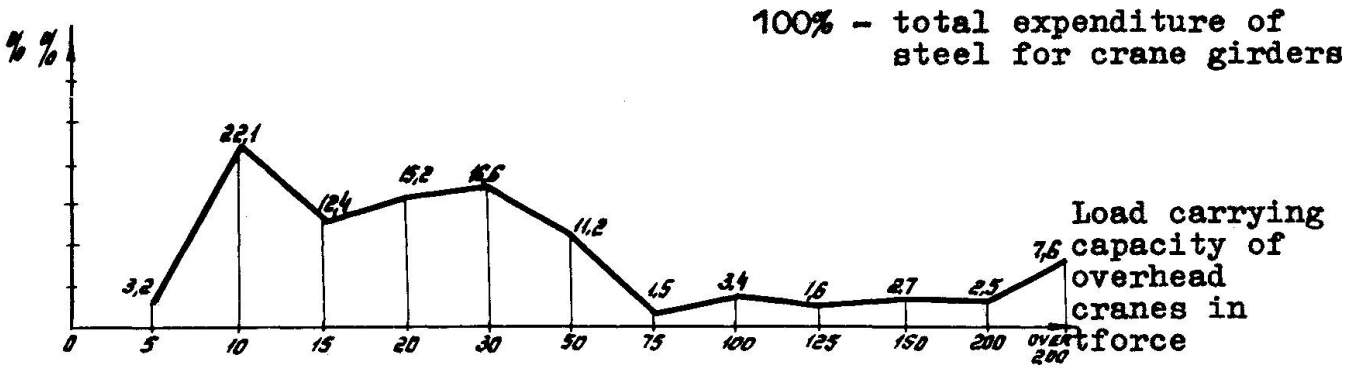


Fig.4. Use of crane girders in per cent in terms of load carrying capacity of overhead cranes

To give a correct estimate to the development of standardization and unification it is necessary to take into account some specific features of the U.S.S.R. which essentially increase variety of types in the structures for mass construction, namely: presence of permanently frozen soils and "sedimentary" soils (soils which are characterized by sedimentation in wetting) and regions with high snow and wind loads, high seismic loads and low temperatures (up to - 65°C).

A wide introduction of carrying precast reinforced concrete structures into the construction field and some limitations in the steel use during a definite period have brought to a nearly complete refusal from steel structures in the undustrial buildings with light and medium cranes. In connection with it the range of steel framework application in buildings was sharply reduced and the steel structures were transferred from the range with high recurrence to the range with low recurrence; it gave additional difficulties in standardization of steel structures.

The progress in the ferrous metal industry providing for increase of steel melting, steel application in construction and also technical and economical studies carried out by some enterprises according to a common plan and intended to determine efficiency and the range of rational application of the structures made of different materials in buildings and installations permitted recently to eliminate some limitations and considerably extend the limits of expedient use of steel in the industrial

building frameworks and for the installations.

At present the following nomenclature of standard steel structures for single-storey industrial buildings is used in the U.S.S.R.:

1. Roof trusses and trusses under roof with the use of steel profiled galvanized flooring, precast reinforced concrete slabs 1,5 x 6; 3 x 6; 1,5 x 12 and asbestos-cement corrugated sheets in case of the building bays equal to 18, 24, 30 and 36 m.

2. Monitors for lighting and aeration and aeration monitors.

3. Columns for the buildings with cranes of load carrying capacity from 5 to 160 tforce with column spacing equal to 6 and 12m and height from 8 to 22,6m for the same 4 bays.

4. Noncontinuous and continuous crane girders under cranes of load carrying capacity up to 200 tforce in case of girder spans equal to 6,12 and 24 m.

5. Girders for suspended transport ways; girder span is 6 m; cranes of load carrying capacity from 1 to 5 tforce.

6. Maintenance and transition platforms and stairs.

7. Window and monitor sashes.

The members of standard structures are worked out for usual conditions of application, for application in regions with increased seismic load conditions (7, 8, 9 points) and also for regions of Siberia and the far North. (Design temperatures of operation and erection -40°C and under).

Use of two types of steel is provided in these structures:

a) Low-carbon conventional steel of "C24" class. (In this case and subsequently the number of steel class is equal to a rated yield point in kgf/mm2);

b) Low-alloy steel of "C35" class.

The structures with a combined application of steel are widely used in standard structures, e.g.:

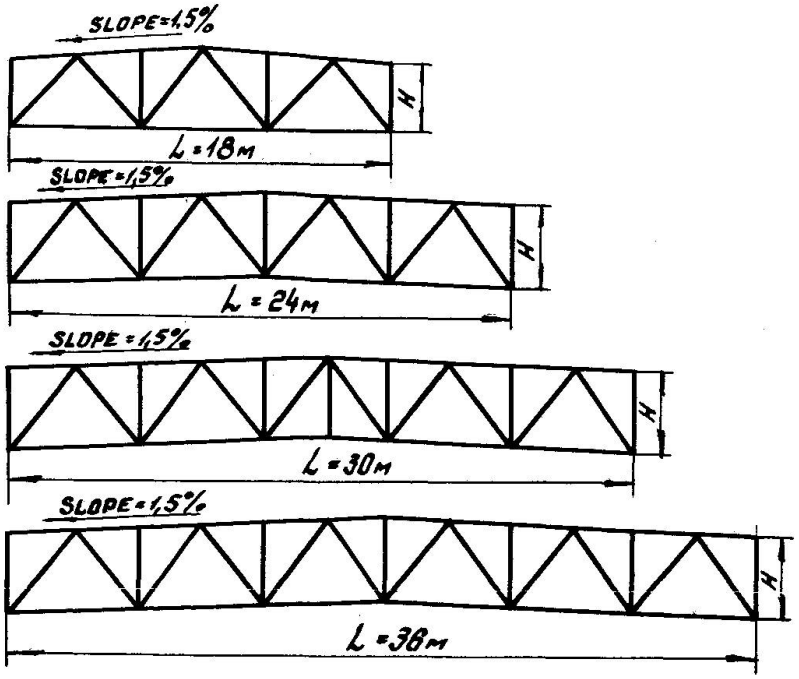
- roof latticed trusses with chords of steel of "C35" class and lattice of "C24" class steel;

- crane girders of welded I-beam sections with chords of "C35" class steel and wall of "C24" class steel.

Open and closed cold-rolled shapes are widely used together with hot-rolled shapes.

The shop connections of members are designed to be welded by means of electric-arc and resistance welding. The field connections are welded by means of electric-arc welding and bolted by means of convenient and high-strength bolts.

The principal parameters of standard steel columns, roof trusses and crane girders are given in fig. 5, 6, 7.



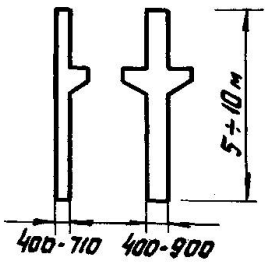
The structural material:
Chord-steel of class "C35"
Lattice-steel of class "C24"

Shapes being used
-hot-rolled angles

Joint connections
Electric arc welding

Fig.5 Diagrams of standard roof trusses

a) Plate columns

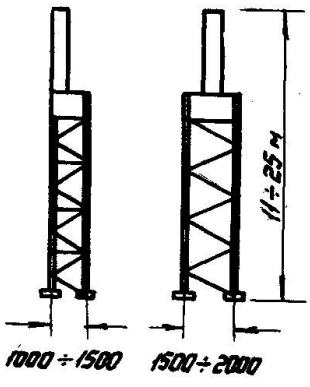


The structural material
Steel of class "C24"

Shapes being used
Welded I-beams

Connections
Electric arc welding

b) Latticed columns



The structural material
Steel of class "C24" or "C35"

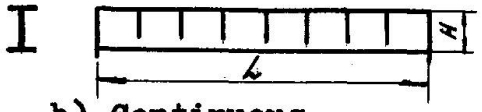
Shapes being used
Top-welded I-beams

Branches of bottom part-rolled or welded I-beams; lattice-hot--rolled angles

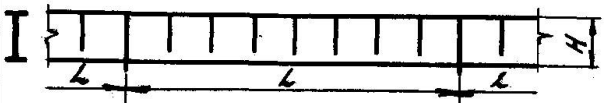
Connections
Electric arc welding

Fig.6 Diagrams of standard columns

a) Non-continuous



b) Continuous



Span of girders;height
L=6;12;24m; H=700-2900mm

The structural material
1. Light and mean duty
Chords-steel of class "C35".
Wall-steel of class "C24"

2. Heavy duty
Chords and wall-steel of class "C35"

Shapes being used
Welded I beams

Connections
Electric arc welding

Fig.7 Diagrams of standard crane girders

As it was already mentioned, the existing standard steel structures are designed to be used in all-steel frameworks as well as in combination with standard reinforced concrete structures. So, for example, steel monitors for aeration and lighting are provided to be placed on both steel and reinforced concrete roof trusses.

The steel roof trusses and trusses and also steel crane girders are provided to be placed on both steel and reinforced concrete columns.

Since 1962 when the 1-st catalogue of standard steel structures for industrial buildings was issued, the nomenclature of members for structures of roof has been essentially changed.

The demand for structural steelworks, considerably increased for the last time required an accelerated construction of new large-scale works and a simultaneous development of the technological procedure of manufacturing in the enterprises which are in operation and which are to be put into operation.

A complex consideration of all steel structures which shall be manufactured during a year and their classification based on the principle of community for equipment being used, fitting out and technological procedures permitted to realize a primary specialization of works according to types of structures.

In this case it became possible to use more narrow specialization of shops, bays and sections for production of members of the same type and arrangement of their continuous high mechanized manufacture in some works.

To the greatest extent it is correct for the standard steel structures of single-storey industrial buildings.

The achived volumes of actual using standard structures in manufacturing and a forecasted further increase of volumes with a simultaneous reduction in the number of standard sizes provide a continuous steady operation of narrow-specialized continuous production lines.

To realize the above-mentioned development of the production field research, experimental and design works are intensively carried out in the U.S.S.R. to establish specialized continuous production lines, sections, shops and the whole plants.

On a large scale the works are carried out to improve structural solutions of standard steel structures, introduce efficient shapes (electric-welded thin-walled pipes, open and closed cold-formed shapes, wide-flange I-beams and profiled flooring) and high-strength steels and also to improve technological properties of standard structures for their adaptation to a mechanized continuous production process of manufacturing.

At the same time great attention is given to working out of efficient types of connections with the use of both resistance and automatic arc welding and also high-strength and convenient bolts.

Some aspects of development and use of standard steel structures for frameworks of single-storey industrial buildings of mass purpose are described in the report. Over a half of all steel structures being manufactured in the country is

consumed by this variety of industrial construction. But the whole volume of works on standardization and unification in the field of structural metalworks is not covered by this.

Separate types of steel installations are characterized by extremely great recurrence; in connection with it the standard structures are to be worked out for them and to be used.

The aforesaid applies first of all to the tanks for different liquids and gases, antenna devices of communication, supports of electric transmission lines, conveyer galleries and supports of pipe-lines.

The problems of standardization for these specific installations are of great interest, however are not covered by this report.

SUMMARY

1. The structural steelworks are widely used in mass industrial construction of the U.S.S.R.

2. The principal direction of unification in the U.S.S.R. is development of standard members for the structures (trusses, columns, beams, etc.) of mass purpose.

3. The continuous development of standard structures and the increase of their recurrence (reduction of standard size number) have established at present bases for transition to manufacturing of structures in automatized continuous production lines.

RESUME

1. Les structures en acier sont largement employées pour les constructions industrielles de l'URSS.

2. En URSS, on tend principalement à standardiser les éléments de structures (treillis, colonnes, poutres) pour les produire en grande série.

3. Le développement continuel de la construction d'ouvrages standards et l'accroissement des séries (réduction du nombre des variantes) ont conduit à l'automatisation de la production.

ZUSAMMENFASSUNG

1. Stahlbauten werden in der U.S.S.R. weitgehend nach industrieller Massenverfertigung verwendet.

2. Die Hauptrichtung der Vereinheitlichung in der U.S.S.R. ist die Entwicklung von Standardbauteilen für die Konstruktion (Fachwerke, Stützen, Träger usw.) zum Zwecke der Massenfertigung.

3. Die dauernde Entwicklung von Standard-Bauwerken und deren vermehrte Wiederkehr (Reduktion der Zahl der Standardgrössen) hat gegenwärtig zu Grundlagen für den Uebergang zur Fabrikation von Stahlbauten in automatisierter Fliessfertigung geführt.