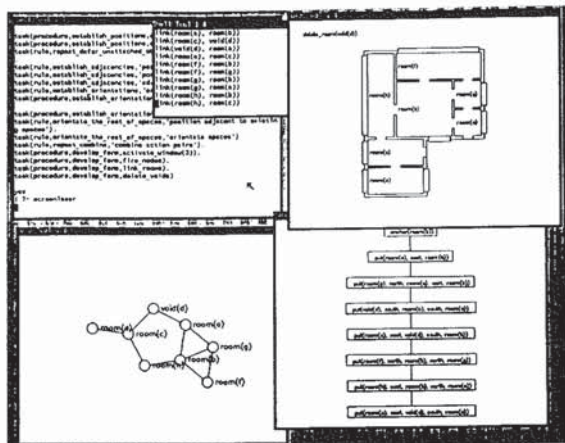


3. A screen image of the OPTIMA system. The graphics window shows a mobile-home plan graphically input to the system. The top left window shows the optimization model constructed to find optimal dimensions of the layout. The bottom left window lists the information generated from the algebraic model. The bottom right window shows the final results with the decisions listed.



4. Screen dump of the various stages in an expert planning system for the design of room layouts.

Perfection of Designing Technology of Unified Reinforced Concrete Structures of Industrial Buildings at the Basis of Optimal and Computer Design

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KEYWORDS

Automatized Design, Industrial Construction, Optimization, Reinforced Concrete Structures, Technological Line, Unification

ABSTRACT

The system of unified structures particularly reinforced concrete ones is the basis of industrial building construction in the Soviet Union. Efficiency of this system is ensured by definite methods at each stage of their development, their manufacturing and erection as well. TsNIIpromzdaniy has worked out a methodology of optimal designing including general approach to the designing of catalogue of unified structures, economical/mathematic models of design projects, methods of obtaining initial information and search of optimal solution. This methodology covers all analytical stages of the design process. Application of this methodology contributes to 8-10 % reduction of unified structures cost. Modelling of projects and tasks allowed to formalize the process of design and interpret it as the problem of plotting the catalogue of unified structures. Automated "TLP TZhBK" system intended for computer designing of unified (standard) precast reinforced concrete structures for the construction of single- and multi-storey industrial buildings has been worked out. When applying "TLP TZhBK" system the functions of designers include: elaboration of technical specifications for design, filling in the incoming documents of the system; analysis and taking the solutions at intermediate stages of automatized design and choice of the final version. Design documentation on manufacturing of structures and auxiliary materials which simplify the designing of projects is the result of automatized design.

Perfectionnement de la technologie d'étude des structures en béton armé standardisées des bâtiments industriels basé sur les méthodes d'étude optimale et l'application des calculatrices électroniques

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Construction Industrielle, Étude Automatisée, Ligne de production, Optimisation, Standardisation, Structures en béton armé

SOMMAIRE

Le système des structures standardisées en particulier, des structures en béton armé prefabrique sert de base de la construction industrialisée des bâtiments industriels en URSS. L'efficacité de ce système est obtenue par l'application des procédés définis aux étapes de l'élaboration des projets, de la fabrication et du montage des structures. A TsNIIpromzdaniy on a mis au point la méthodologie d'étude optimale concernant l'approche générale de la création du catalogue des structures standardisées, les modèles économiques/mathématiques des objets d'étude et les méthodes de l'obtention de l'information initiale et de la recherche de la solution optimale. La méthodologie embrasse toutes les étapes analytiques du procédé d'étude et permet de réduire le coût des structures de 8-10%. La simulation des objets et des problèmes a permis de formaliser le processus d'étude et de l'interpréter comme problème de la création du catalogue optimum des structures standardisées. Sur cette base a été étudié le système automatisé "TLPTJBK" élaborant des projets des structures en béton armé standardisées par les calculatrices électroniques (poteaux, linteaux, poutres, fermes, dalles de plancher et recouvrement) pour la construction des bâtiments de production élevés et sans étages. Les techniciens d'études utilisant le système "TLPTJBK" font les opérations suivantes: élaboration des normes techniques d'étude, remplissage des documents d'entrée du système, analyse et prise des résolutions aux étapes intermédiaires de l'étude automatisée et choix d'une variante définitive. L'emploi de l'étude automatisée permet d'obtenir la documentation d'étude pour la fabrication des structures et la documentation auxiliaire, simplifiant l'étude des objets de la construction sur la base du catalogue standardisé.

The system of unified structures particularly reinforced concrete prefabricated ones is the basis of industrial building construction in the Soviet Union. More than 80 % of superstructures are unified.

Efficiency of unified structures system is ensured by definite methods at each stage of their development (including designing) their manufacturing at precast reinforced concrete plants, their application at construction sites, planning and organization of system's development as well.

Each type of precast reinforced concrete structures is characterized by assortment or by parametrical series of products of a single type which are differed in general by geometry and load bearing capacity.

The problem of designing of economic unified structures should be regarded as the problem of designing of optimal assortments.

Assortment of unified structures is designed on provision of servicing of the given field of application. It is a prerequisite to the basis of general approach of TsNIIpromzdaniy to the designing of optimal assortment. The above mentioned field of application is described by ranges and gradation of numerical values of characteristics of construction regions, conditions of maintenance, structural parameters of the buildings and distribution of volumes of construction by parameters of the field of application. In consequence of discreteness of these parameters the field of application may be easily conceived as a finite set of unified design situations. Assortment whose application for the specified set results in the minimum expenditures for construction is considered to be optimal. Designing of such an assortment, or series, may be regarded as the solution of a discrete integral-valued problem of mathematical programming meeting the conditions of functioning the system of unified structures (production, conditions of application, field of application, demand for series elements).

Efficiency function is plotted as the dependance of the optimality criterion (reduced costs, as a rule) from the number and volume of production of optimal series elements. The conditions of the task describe the conditions of satisfying of all kinds of demand in specified volume providing for limitation of using of each element in specified field.

The determination of initial information incorporates: obtaining the list of unified design situations and demand for them; plotting of initial parametrical series of products (to be optimized) including determination of technical and economical characteristics of its elements; determination of application conditions of elements of the initial series of the given field. Realization of this field is an independant and rather labour

consuming task for whose solution the use is made of conventional as well as specially developed methods and programmes.

Choice of the optimal solution is made on the basis of traditional methods (dynamic programming, method of branches and borders) as well as by algorithms of heuristic character depending on assortment model. For large-sized tasks the use is made of the method of statistical tests.

Fig. 1 shows the process of designing the optimal assortment of the frame-work elements of a multi-storey buildings.

Wide experimental verification of this methodology revealed the possibility of 8-10 % reduction of construction cost by using unified structures.

The given methodology in combination with system of interconnected models of design projects and mathematic methods of the choice of optimal solution including models and methods of obtaining necessary initial information represented a means of formalization and algorithm representation of the process of optimal design of unified structures. Automatized "TLP TZhBK" system intended for the designing of unified (standard) precast reinforced concrete structures for the construction of single- and multi-storey industrial buildings has been worked out and put into operation in 1982 at this basis. Table 1 shows the generalized structural model of this system reflecting the connection between the projects (structures) and problems (stages) of design.

Programming has a modular structure complying with the scheme shown in Table 1. It permits to produce various objective subsystems in conformity with design assignments at the basis of limited number of design modules. It ensures the definite flexibility of the system.

The single data basis and its application for the exchange of information between the individual programming modules in combination with some amount of service programmes allowed to realize the complex realization of the design process of unified structures and to achieve the considerable reduction of labour consumption in designing.

The system is designed for the receiving of optimal solutions at all the levels of taking decisions: when developing an individual element, when plotting an assortment of structures of the given type and when arranging the frame-work from a set of the elements. Programming complex of statistical modelling of technical/economical characteristics of structures permits to solve a great number of problems by forming the variants of decision differing by initial conditions of assortment plotting (a number of structures in assortment row, the characteristics of design, restrictions on the resources and etc.) actually

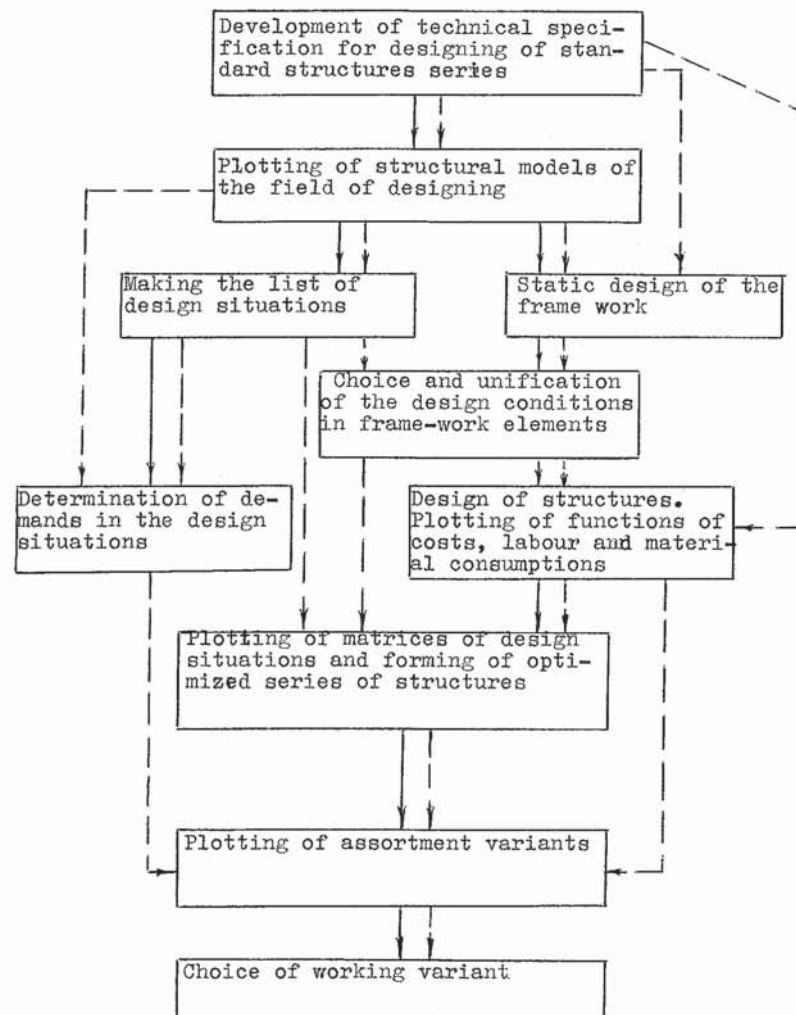


Fig. 1

Table 1 Structural model of automatized "TLP TZhBK" system

Structure of functional subsystems		Structure of design project							
I level	II level	Multi-storey industrial buildings				Single-storey industrial buildings			
		frame-work columns	girders	slabs	braces	frame-work columns	trusses	beams	slabs
Static and dynamic structural design	Design of linear-elastic systems	•				•		•	
	Design of non-linear systems	•				•		•	
	Choice of combination of design forces	•	•	•	•	•	•	•	•
	Choice of the unfavourable loading	•				•			
Designing of structural elements	Designing of structural parameters		•	•	•		•	•	•
	Constructing		•	•	•		•	•	•
Statistic and technical/economical values	Making the list of design situations	•	•	•		•	•	•	•
	Determination of demands in design situations	•	•	•	•	•	•	•	•
	Plotting of functions of costs, steel and labour consumption		•	•	•		•	•	•
Optimal unification of structures	Plotting of matrices of design situations and optimized series of structures		•	•			•	•	•
	Plotting of optimal series of structures		•	•	•		•	•	•
Materials of design	Forming of marking schemes		•	•	•		•	•	•
	Determination of the load-bearing capacity of the element		•	•	•		•	•	•
Automatized graphic conclusion	Working structural drawings		•	•	•		•	•	•
	Materials for design	•	•	•	•	•	•	•	•

with the same design costs. Economic assessment of the design structures is the obligatory element of the solution.

The main technical data on "TLP TZhBK" system may be presented as follows:

- a number of design modules - 47
- volume of programming - 14.6 MB
- volume of data basis - 9.4 MB
- languages of programming - FORTRAN and PL-I

The system is operated by the specially trained personnel of the Computer centre.

When applying "TLP TZhBK" system the functions of designers include: elaboration of technical conditions for design, filling in the incoming documents of the system; analysis and taking the solutions at intermediate stages of automatized design and choice of the final version.

The described technology of man/computer design permits to obtain the following final design documentation and materials for design: catalogue, structural parameters, characteristics of load-bearing capacity and technical/economical values of unified structures, the schemes of completing the frame-works with catalogue products.