

Automated Designing of Load Carrying Reinforced
Concrete Structures for Public and Industrial Buildings

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ABSTRACT

This paper contents a description of directions of the developing of automated designing of the structural part of engineering objects. Here also is done a description of the versatile automated system LIRA, which is calculated practically of all the types of structures to be designed. This automated system realizes the super-elements method. The calculations are being performed for the static and dynamic loads. In the calculation of structures we can have into account the geometrical and physical nonlinearity. The developed service part of the automated systems minimizes the period of time required for mastering it. There also is a description of KALIPSO - the Technological Line for Designing of the structural part of multistrayed public and civil buildings. This TLD KALIPSO is intended to be automated all the complex of works for the structure parts of the project to be designed: calculation of the spatial building framework, elaboration of the erection diagram drawings, designing of the individual elements and monolithic sections, elaboration of the specifications and documentation access.

L'automatisation de la conception des
constructions portantes en béton armé pour les
bâtiments civils et industriels.

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MOTS CLÉFS:

Automatisation de la conception, Charges, Constructions portantes,
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Sommaire:

Le rapport expose les tendances du développement de CAO de la partie constructive des objets de construction. On décrit le système de calcul universel "LIRA" destiné à l'utilisateur de masse et assurant l'automatisation du calcul pratiquement de tous les types des constructions à concevoir. Ce système automatisé réalise une méthode des supers-éléments. Le calcul est effectué pour les charges statiques et dynamiques. Lors du calcul des constructions on peut aussi tenir compte de la non-réalité géométrique et physique. Le domaine de service développé du système assure le délai minimal de son assimilation.

On décrit aussi la ligne technologique "KALIPSO" destinée à la conception automatisée de la partie constructive des bâtiments à plusieurs étages aux schémas des carcasses liées. La ligne technologique "KALIPSO" est prévue pour l'automatisation de tous les travaux concernant la conception de la partie constructive: calcul du schéma tridimensionnel du bâtiment, établissement des schémas de montage, conception des éléments individuels et des sections monolithes, formation des spécifications et choix des documentations.

Automated designing of load carrying reinforced concrete structures for public and industrial buildings

In the Ukrainian Soviet Socialist Republic the automated design of load carrying reinforced concrete structures for public and industrial buildings is developed by different directions. One of them is represented by the elaboration of the versatile computer complex, which is calculated for a general user, and provides the automated calculation practically of all the types of structures to be designed, choosing the most convenient engineering designs and saving materials.

The elaborations are being performed for the multicomputer systems of common conceptual positions based on flexible technological lines of designing, each of them automates all the complex to be designed the structure part of project of certain type of buildings.

The automated complex LIRA provides the calculation and numerical investigation of a wide range of structures: spatial framed structure systems, random laminated system (beam-walls, plates, and shell structures), membranes, stay rope systems, massive bodies, combined systems (plates resting on soil base, ribbed laminated systems, multilayer structures, etc).

The investigated objects can possess arbitrary curvilinear outlines, local reductions of their strenght in the form of a different shape of holes and cavities, various conditions of supporting.

Calculating the structures, the nonlinear dependences between stresses and strains can be taken into account which are determined by substantial variation of a structure shape (geometric nonlinearity), phenomena of plasticity, creepage and shrinkage (physical nonlinearity).

The calculation of structures is to be performed for static and dynamic loads. The dynamic loads simulate the effects resulting from an earthquake, pulsating flow of wind vibrational actions from production equipment, impact, and impulsive actions.

The AS LIRA comprises the modules which automate a number of designing processes: choice of unfavourable combinations of loads, unification of elements in stright, optimum reinforcement of sections of reinforced concrete structures, compilation of erection diagrams of the structures made from standard elements.

The versatility and the easy adaptation for a problem enable

to use the AS LIRA in automation of the designing of various engineering objects:

civil engineering - coverings and floors of large spans, structures of high-rise buildings, retaining walls, foundation bodies, skeleton structures of industrial shops;

bridge building - box-like structures of large spans, pylons and stay rope systems of suspension bridges, bridge piers, tunnels;

special structures - constructions of high-rise towers and masts, telescopes, main pipelines, boilers, hulls and separate fragments of ships, heavy constructions of atomic power engineering.

The AS LIRA implements the numerical method of discretization of continuous medium - method of finite elements (FEM) in connexion with the idea of superelements.

The AS LIRA comprises over 100 different types of finite elements: framed structure elements, rectangular and triangular elements of an isotropic and orthotropic plate, a plate on the elastic foundation, a beam-wall, a shell structure; rectangular and triangular elements of a multilayer plate and shell structure; spatial elements in the form of a tetrahedron, parallelepiped; isoparametric elements of the plane and volumetric stressed state; monometric, triangular and rectangular axisymmetrical elements; triangular and rectangular elements of a beam-wall, plate and shell structure with the anisotopia of the shape; special elements, simulating a tie of finite rigidity, elastic compliance between nodes; elements, set by the numerical stiffness matrix, etc.

The developed library of finite elements, the modern high-speed algorithms of solving the systems of equations and determining the eigen values practically do not impose any restrictions on the tipe and properties of a calculated object and provide an opportunity of solving the problems with a great number of unknown quantities.

The AS LIRA can function within the systems of EC (IBM) and CM (PDP) computers.

The service offered by the AS LIRA enables the wide circle of specialists, engaged in the sphere of designing, to master the work with a computing complex and to include it in their engineer arsenal. The AS LIRA is provided with a sufficiently detailed documentation which facilitates its use and is designed for the specialists of different branches and level of training. The developed service part and the good documentation

minimize the period of time required for mastering the AS LIRA.

The initial data are preset in the compact and habitual for an engineer form on the special blanks, provided with commentaries, which facilitate their filling in.

In the description of design diagrams an opportunity is available of using various systems of coordinates, automatic generation of a computer network and taking into account the axisymmetry of a structure to be designed.

The powerful system of automatic diagnostics of errors, the visual check of entered data on the plotter or graphic display, the automatically yielded recommendations for the optimum organization of execution of a task on the electronic computer (size of task divisions, planned computation time, assignment of breakpoints) ensure a high reliability and speed of obtaining the result.

The obtained characteristics of the stressed-strained state - amounts of displacements, forces, stresses shape and periods of vibrations, data on the zones of plastic strains, sizes and directions of cracks - are output in the tabular form and are provided with the indexing habitual for an engineer.

The output explanatory note comprises a brief description of an investigated object, actual time of the task passage, additional descriptions of the operation results.

The images of design diagrams, load diagrams, isolines and force curves are output to the plotter.

The application of the AS LIRA ensures an efficiency of investigations and designing of civil engineering objects. The investigators are given the possibility to replace expensive life-size tests by the mathematical simulating of the structure tests made in the electronic computer, what enables the experimental investigations of the new types of structures to become more cheap and fast. The designers have the possibility to elaborate the calculation framework with the maximal reflection of the life-size operation of the building, and in such a way to definit with a high level of precision the strainness of the building and the distribution of forces in the structure sections, having into account the cracks formation and concrete creep, plastic strains of the reinforcement, what enables to be provided a high level security of buildings in designing.

An example of the elaboration (upon a base of the particular components of automated design systems) of a technological designing line (TDL) is represented by the TDL KALIPSO, which

is intended for designing of the structure part of many-storeyed structure tied framework buildings.

The TDL KALIPSO provides the designing of a wide range of public buildings: offices, hospitals, educational establishments, hotels and hostels, commercial and communal buildings. The TDL also provides the designing of production and auxiliary buildings of factories (shops and offices).

The designed buildings can be of different shape both in plane and high. The designing is being performed for various conditions of construction.

The TDL KALIPSO is intended to automate all the complex of works to be designed the structural part of the multistoreyed building project: calculation of the building's carrier diagram, elaboration of the erection networks, designing of the individual elements and monolithic sections, elaboration of specifications and documentation access.

The calculation of the carrying structures of the building is being performed in the form of the spatial calculating diagram having into account the compliance of the tied unions, existence of holes in the rigidity diaphragms, compliance of the soil base, alteration in the building's geometry. Depending on the building complexity a different idealization level of the calculating diagram is being used - the consideration of tied unions compliance is being performed either in the form of discrete ties or in the form of integral evaluation of their compliance in the building's height. As the results of the calculation of the building carrying structure are being obtained: marks of columns, diagrams and cross-bars in carrying capability.

The TDL KALIPSO enables to be obtained all the complete set of the graphical design documentation: the erection diagrams of coverings and floors for each storey, erection diagrams of the wall fences allotment, erection diagrams of the longitudinal and transverse sections, diagrams of the cross-bars allotment.

The erection diagram drawings are being completed with the drawings of the individual reinforced concrete pieces - columns, cross-bars, rigidity diaphragms, monolithic sections of the floors.

The TDL KALIPSO consist of a serie of sub-systems: CALCULATION FLOOR, WALL, FRAMEWORK, INDIVIDUAL ELEMENTS; being as components of the TDL they can also operate on the computers EC and CM. There was also foresaw a possibility the designing process to be devided between computers of the different productivity.

The more complex designing sections (calculation and erection diagram elaboration), requiring a lot of machine resources and implementation of a high speed computer are being performed on the models EC and ones less complex sections (individual elements designing) can be performed on the models CM.

During the TDL KALIPSO elaboration the experiences of the AS LIRA elaboration were used in a wide scale. The certain AS sections and modules were included as components in the TDL. The initial data also are preset in a compact and habitual for an engineer form on the special blanks. On a level with presetting of the initial data from a different media are also being used the alphanumeric and graphical displays coder. There is a developed system of automated error diagnostics, visual control on the plotter or graphic display of the data presetting.

The TDL KALIPSO application provides a further (in respect of the AS LIRA using) elevation of the efficiency of designing of engineering objects.

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UTILIZATION OF DECISION MODELS UNDER UNCERTAINTY
FOR THE ANALYSIS OF BUILDING ENERGY SIMULATION RESULTS

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ABSTRACT

In current energy analysis techniques, usually a deterministic relationship between the weather conditions and the building thermal loads is assumed. In passive system applications, the thermal behavior of a building could be better analyzed if uncertainty related to weather conditions is taken into consideration. In this paper, different design alternatives of an office building in Montreal are evaluated using a research oriented software developed at the Centre for Building Studies. The simulation results are analyzed using decision models under uncertainty. The best design is defined to provide the minimum thermal load and the thermal comfort within acceptable limits. The results indicate that the attached unheated solarium on the south wall reduces the space load by 40% with respect to the conventional design.