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# SOLUTION TO THE PROBLEM OF OPTIMAL DESIGN OF AN ELEVATOR WORKING TOWER UNDER DYNAMIC LOADS

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**Abstract. Purpose.** The purpose of the paper is to develop and substantiate an approach to the optimal design of steel-reinforced concrete floors in elevator working towers subjected to dynamic loads generated by grain-cleaning machines. The study aims to formulate a mathematical model of the optimization problem, define a system of generalized design parameters, and establish a methodology for their rational selection under strength and serviceability constraints. Particular attention is given to the application of the Hooke-Jeeves direct search method in combination with limit state design principles for optimizing key structural parameters, including slab thickness, floor beam spacing, stud connector characteristics, and reinforcement configuration. The research also focuses on accounting for dynamic effects arising from different operating modes of separator machines within the overall design framework of composite floor systems.

**Methodology.** The research is based on a combined approach that integrates limit state design calculations with the Hooke-Jeeves direct search method for optimizing the structural configuration of steel-reinforced concrete floors. A mathematical model of the optimization problem is formulated, including an objective function based on bending stresses and constraints defined by nonlinear equilibrium equations, strength conditions, and permissible ranges of design parameters. The set of generalized design variables includes slab thickness, floor beam spacing, stud connector diameter, and reinforcement characteristics, while key geometric parameters of the structure are treated as fixed inputs. The optimization procedure involves iterative variation of individual parameters with subsequent evaluation of the structural response under combined permanent, variable, and dynamic loads generated by grain-cleaning machines operating in different modes.

**Results.** The application of the proposed optimization methodology enabled the formulation of a structured procedure for determining rational parameters of steel-reinforced concrete floors in elevator working towers. A base point of the optimization process was established, along with permissible ranges for variation of the main design parameters, including slab thickness, floor beam spacing, stud connector diameter, and reinforcement characteristics.

**Scientific novelty.** The scientific novelty of the study lies in the development of an integrated approach to the optimal design of steel-reinforced concrete floors

*in elevator working towers, which combines limit state design principles with the Hooke–Jeeves direct search optimization method.*

*A distinctive feature of the proposed approach is the explicit consideration of dynamic loads generated by grain-cleaning machines operating in different modes, which are incorporated into the optimization framework. This allows for a more accurate representation of real operating conditions compared to conventional static design methods. The study also establishes a structured procedure for parameter variation and search direction identification within the design space, forming a basis for further development of optimization techniques for composite steel–reinforced concrete systems.*

**Practical relevance.** *The proposed approach can be applied in the design of steel–reinforced concrete floors in elevator working towers and similar industrial structures subjected to dynamic loads from technological equipment. The developed methodology provides engineers with a systematic tool for selecting rational design parameters, including slab thickness, beam spacing, stud connector characteristics, and reinforcement layout, in accordance with strength and serviceability requirements.*

*Its implementation enables a more reliable consideration of dynamic effects during the design stage, contributing to improved structural safety, durability, and operational performance. The approach can be integrated into existing engineering practice and adapted for use in numerical modeling environments, facilitating more efficient decision-making in the design and modernization of grain processing facilities.*

**Keywords:** *steel–reinforced concrete floors, elevator working towers, dynamic loads, grain-cleaning machines, structural optimization, Hooke–Jeeves method, slab design, vibration reduction.*

## INTRODUCTION

The evolution of composite steel-concrete structures over the past century has progressed from utilizing concrete primarily for fireproofing to the development of high-performance systems where reinforced concrete slabs and steel beams act integrally. This synergy has become a decisive factor in the success of modern high-rise construction. Today, composite construction is recognized as a distinct structural form with its own comprehensive regulatory framework, most notably Eurocode 4 (EN 1994). Design methodologies have transitioned from the application of basic mechanics to a sophisticated understanding of the specific nuances of material interaction. Contemporary technical literature focuses on elucidating the theoretical foundations of advanced concepts, such as the behavior of semi-rigid and partial-strength connections, the buckling resistance of composite elements, and the analysis of two-way spanning floor systems and non-sway frames. This holistic approach, tracing the development from fundamental components to complex integrated systems, enables engineers to move beyond conventional empirical solutions toward intelligent, optimized design that ensures superior structural efficiency and reliability [10].

## ANALYSIS OF PREVIOUS RESEARCHES

Significant contributions to the study of the performance of composite

steel-concrete structures have been made by prominent domestic and international scientists. L.I. Storozhenko laid the foundations of the scientific school of composite structures in Ukraine, developing fundamental approaches to the design of such systems at the Poltava Polytechnic [28; 29]. The development of numerical methods for optimizing the parameters of slabs and beams, specifically through the application of the Hooke–Jeeves method, is reflected in the works of O.V. Shymanovskiy and O.I. Lapenko, who employed this algorithm to determine rational geometric characteristics for composite elements in stay-in-place formwork [25; 29; 31]. Issues regarding probabilistic analysis and the practical implementation of these structures were addressed by O.V. Semko [26]. Substantial contributions to the research on the strength and deformability of flexural members were made by M.Yu. Izbash [23]. Among international scholars, R.P. Johnson made a major impact on the theory and optimization of composite structures, with his work serving as a cornerstone for the Eurocodes, alongside K. Roik, who focused on the shear resistance of connections [8; 22]. The problems of automated design and optimization of composite structures using direct search methods were further explored by D.A. Nethercot and M. Patrick, whose research focused on analyzing the performance of profiled sheeting as external reinforcement

and establishing criteria for the optimal design of floor systems.

The application of composite steel-concrete systems is widespread within the agricultural sector, specifically in the structural design of grain processing working towers, where they provide an optimal balance between material consumption and rigorous operational requirements. The working tower is a multi-tier industrial structure with plan dimensions of 12.0 × 29.0 m and a total height of 48.4 m (to the roof ridge). The structural frame of the working tower supports waste discharge hoppers for road transport, conveyor galleries, as well as separator machines located at elevation +16.600, which generate dynamic loads. Structurally, the working tower consists of two parts: the section within grid lines 1–3/A–D, which forms the main structure, and an annex on an independent foundation within grid lines 1–3/D–E. As an example of application, the working tower of a grain elevator in the Ternopil region is considered; the layout of the load-bearing steel elements and the floor plan at elevation +16.600 are shown in Fig. 1.

The working tower within grid lines 1–3/A–D represents a steel column-and-beam braced system with technological platforms arranged at different elevation levels: within grid lines 1–3/A–B the top elevation of the tower is +32.200, while within grid lines 1–3/B–D the top elevation reaches +47.300.

A working tower of this functional purpose consists of a deck, a system of load-bearing beams (beam cage), columns, vertical bracing members, staircases, and guardrail systems.

During the design process, several configurations of the beam cage may be developed using steel or reinforced concrete decks.

The spacing of floor beams varies depending on the deck material and the convenience of subdividing the span of the main beam in a conventional beam cage system and ranges from 0.6 to 1.8 m for steel decking and from 1.5 to 3.0 m for reinforced concrete decking.

The floor structures of the working tower have several structural solutions determined by the technological process. The floor at the locations of the separator machines at elevation +16.600 is designed as a monolithic steel-reinforced

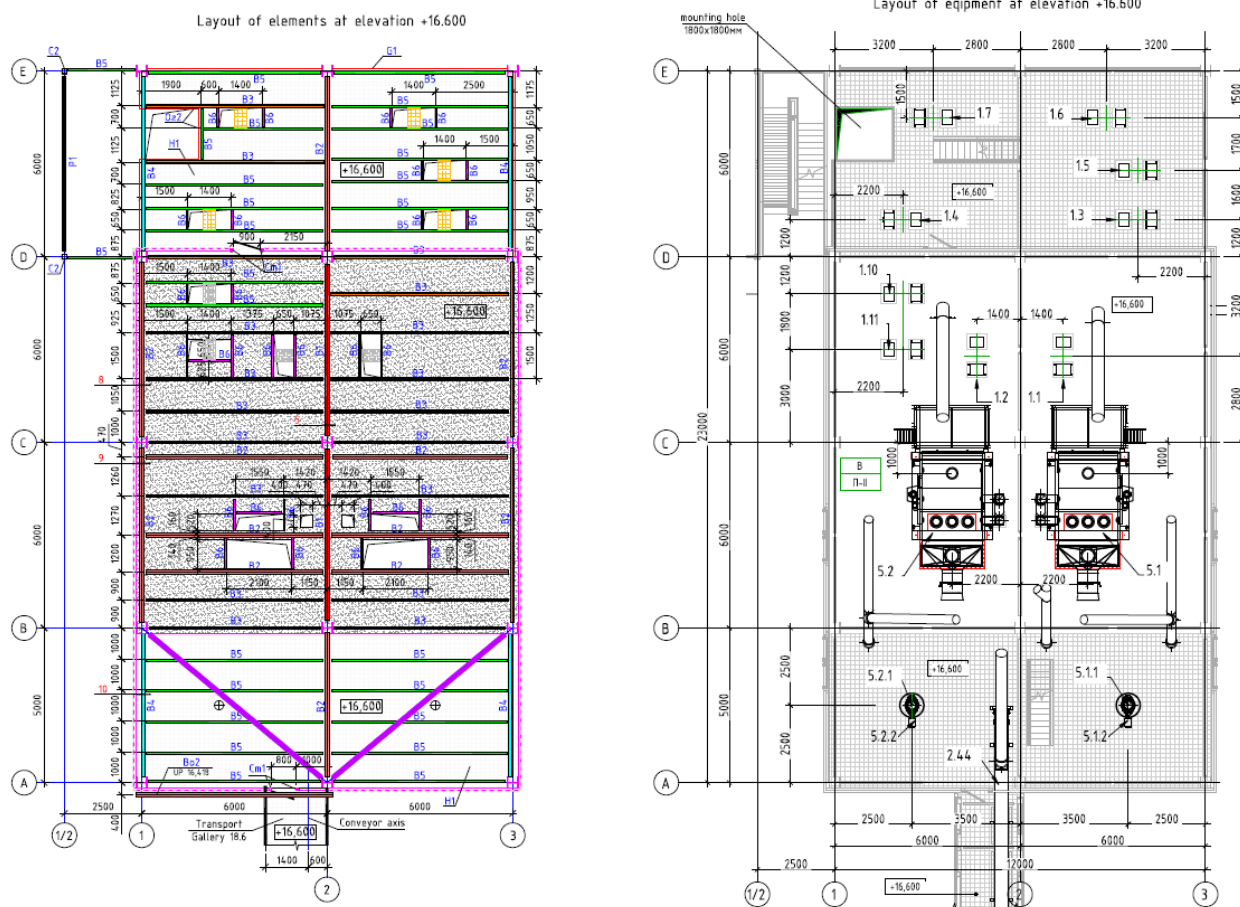


Fig. 1. Layout of load-bearing steel elements and the plan at elevation +16.600 [14]

concrete slab with a thickness of 200 mm cast on profiled steel decking. This floor is supported by main beams arranged along the longitudinal and transverse grid lines, as well as by floor beams spaced at intervals ranging from 0.9 to 1.5 m. Other floors are designed as a system of main beams and floor beams with various cross-sectional types (channels and I-beams), supporting a grating deck [26; 16].

The longitudinal and transverse stability of the structural frame is ensured by vertical bracing along the columns and beams. All structural elements are connected by pinned joints using standard-precision bolts and by erection welding.

Two-flight staircases are provided for access to the technological platforms and are arranged separately within grid lines 1/2–1/G–D (see Fig. 1).

In order to obtain an optimal floor structure at elevation +16.600 of the elevator working tower with given parameters of the grain-cleaning machines, an optimization problem of the steel-reinforced concrete floor structure was formulated and solved. Two grain-cleaning machines are installed on the separator floor (Fig. 1), which results in increased dynamic loads and a potential risk of resonance wave occurrence.

## PURPOSE

The purpose of the paper is to investigate the optimal design of a steel-reinforced concrete floor in the working tower of a grain elevator subjected to dynamic loads from grain-cleaning machines. The study focuses on developing a mathematical model of the optimization problem and determining the main design parameters of the composite floor structure. The methodology combines limit state design calculations with the

Hooke–Jeeves direct search method to optimize key structural parameters, including slab thickness, floor beam spacing, stud bolt diameter, and reinforcement characteristics, while considering dynamic effects generated by separator machines during different operating modes.

## Research methodology

In solving the problem, an approach was developed that combines strength calculation methods based on the limit state design concept with a direct search method for optimizing the structural configuration of the steel-reinforced concrete floor, subject to strength constraints and generalized design parameters [22; 24; 31].

The mathematical model of the problem is formulated as follows:

objective function:

$$f(b, u) = \sigma_{\max}^{33(\text{bend})}(b, u) \min; \quad (1)$$

constraints in the form of equalities (a system of nonlinear equilibrium equations):

$$h_k(b, u) = 0; \quad (2)$$

constraints in the form of inequalities:

$$\max \sigma(B, u) \leq |\sigma_r|; \quad (3)$$

$$\{b^0\} \geq \{b\} \geq \{b^k\}; \quad (4)$$

where  $\{b\} = \{b_1, b_2, \dots, b_n\}$  – is the vector of design variables;  $\{u\} = \{u_1, u_2, \dots, u_n\}$  – is the vector of state variables (displacement increments).

The structure of the floor includes segments of a monolithic reinforced concrete slab, T92 steel profiled decking with a thickness of 0.7 mm, inserts with

“Nelson” bolts, and slab reinforcement in the form of steel meshes with 10 mm diameter A400C reinforcement bars.

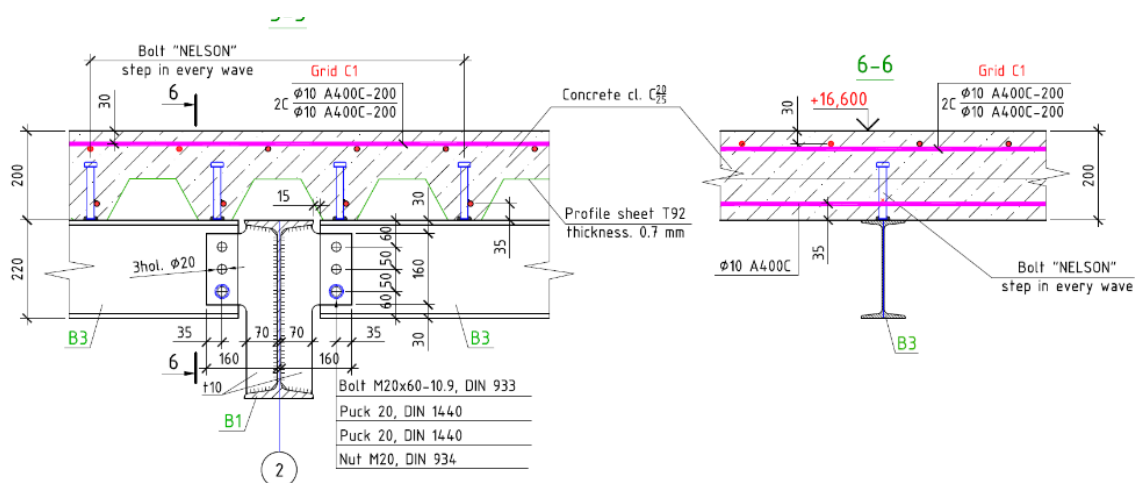


Fig. 2. Joint for beam alignment. Option for designing the beam connection node [14]

Due to the use of predefined dimensions and cyclically repeating structural segments, the number of design parameters is limited, meaning that there is a restricted set of generalized design parameters.

$$t_p, t_{pl}, a_1, d_b, d_a, a_2, f_{cd}, R_y, f_{yd}; \tag{5}$$

where  $t_p$  – thickness of the profiled steel decking in the steel–reinforced concrete floor on the separator floor at elevation +16.600;  $t_{pl}$  – thickness of the monolithic reinforced concrete slab in the steel–reinforced concrete floor on the separator floor at elevation +16.600;  $a_1$  – spacing of the floor beams on the separator floor;  $d_b$  – the diameter of the “Nelson” bolts can vary from 0 (absence of bolts) up to a specified maximum value;  $d_a$  – diameter of the reinforcement in the monolithic reinforced concrete slab;  $a_2$  – spacing of the reinforcement bars in the monolithic reinforced concrete slab;  $f_{cd}$  – design compressive strength of concrete;  $R_y$  – design yield strength of steel;  $f_{yd}$  – design strength of reinforcement [20; 4; 7].

The spacing of the columns in the longitudinal and transverse directions, as well as the height of the working tower with its division into technological levels, are considered fixed input data for the optimal design problem and are therefore  $\{b\}$  not included in the design variable vector.

With a limited number of generalized design parameters and in the presence of strongly nonlinear equality constraints  $\{b_i\}, i=6-10$  search methods (direct optimization methods) [17; 5; 9] are the most effective. These methods are based

on computing the values of the objective function for a given vector of design parameters, with the sequence of parameter adjustments implemented according to a recurrent formula [30].

$$\vec{b}^{t+1} = \vec{b}^t + \delta \vec{b}^t, \quad t=0, 1, 2, \dots, k, \tag{6}$$

where  $t$  – is the iteration number of the direct search;  $\delta \vec{b}^t$  – is the increment of the design parameter vector.

The essence of direct search methods lies in varying one variable (one component of the independent vector  $\vec{b}$ ) at a time, while the remaining variables are kept constant, until a minimum of the objective function is achieved. Given the limited number of design variables, the Hooke–Jeeves optimal direct search algorithm [19] is applied in this study. For the specific problem of optimal design of the separator floor structure, the algorithm takes the following form. The algorithm consists of two main stages:

- an exploratory search in the vicinity of the base point at  $t=0$  (initial point);
- a pattern search, that is, movement in the direction of the greatest decrease toward the minimum value of the objective function.

Figure 3 presents a simplified informational block diagram of the Hooke–Jeeves direct search method [19].

Let us consider the main stages of the algorithm according to the sequence of operations. In addition to the two principal stages of the Hooke–Jeeves search mentioned above, the preparatory stage of optimization is of crucial importance, especially when discrete models of

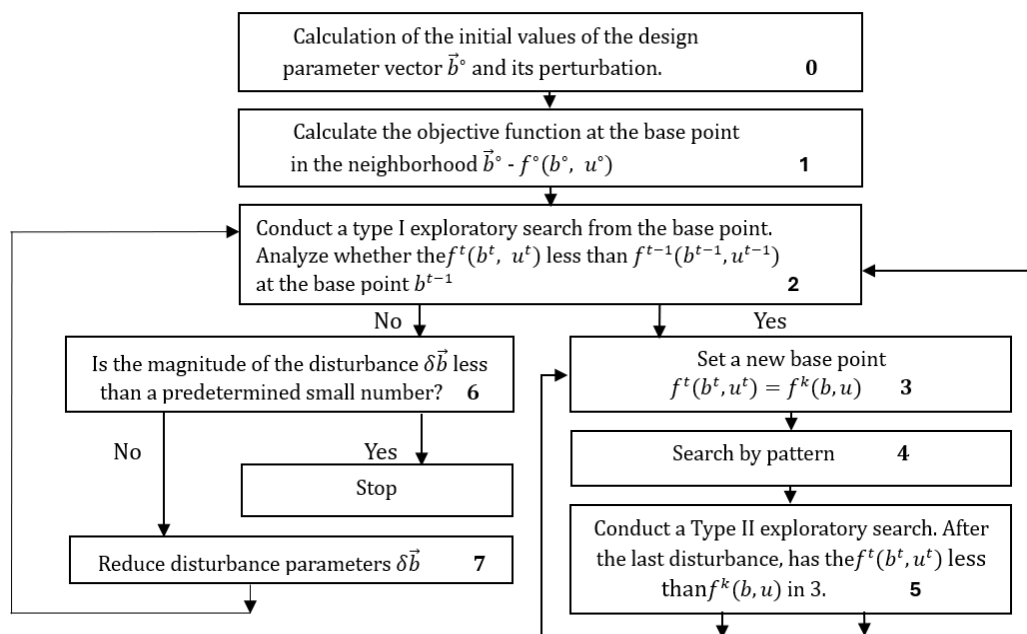


Fig. 3. Information flow chart of direct search [14]

the designed structures and their numerical implementation are employed [23].

The preparatory stage defines the base search point and the bounds of perturbations of the independent components of the design parameter vector. This is also considered by the fact that for a nonlinear structure [24], the optimal design problem, in addition to the design variables, also includes state variables (the mathematical model (1–4), which must be taken into account by the engineer when selecting the initial (baseline) values of the design parameters. The governing state of the mechanical system depends on properly chosen initial values of the design parameters, which in turn depend on the state variables; thus, both sets of variables are interrelated [2; 15; 24; 29].

In order to represent the optimal search algorithm in the form of a nonlinear programming problem, it is in fact necessary to introduce a new variable of the optimal design problem [22; 24; 27; 30].

$$\{z\} = \begin{Bmatrix} u \\ b \end{Bmatrix} \quad (7)$$

Thus, it becomes possible to directly apply nonlinear programming solution techniques, which are well suited to the formulation of governing equations in incremental form when the geometry is updated at each step of the extension process [9].

## RESULTS AND DISCUSSION

For the optimal design problems of the separator-floor slab structures considered above, under complex loading conditions (permanent loads from self-weight, variable loads from equipment weight, and loads induced by separator machines operating in three modes: start-up, steady-state operation, and braking), it is necessary at the preliminary stage of the optimal search algorithm to solve the nonlinear deformation problem. For given fixed parameters, this allows the determination of the structural performance characteristics, sensitivity to various actions, and the required bounds of the main generalized design parameters [27; 19].

The floor structures considered include steel decking, reinforced concrete decking, and composite steel-reinforced concrete decking. Strength assessment, based on the recommendations of regulatory documents and with accuracy sufficient for engineering practice, is performed using the magnitude of bending stresses. Therefore, the analysis of the maximum bending stress function should be regarded as the principal criterion in optimal design, while the primary strength constraint is described by the load function at the ultimate limit state (1).

As a result of a certain number of numerical analyses of the working tower with specified structural and technological characteristics, a base point of the optimal design search for the floor structure is determined, corresponding to specific values of the design parameters. The input data that remain unchanged during the optimization process include the column spacing in the longitudinal and transverse directions, and  $v$  – the circular vibration frequency of the sieve body,  $s^{-1}$ .

The initial values of the components of the vector of independent design parameters are as follows:

$$\{b^0\} = \{b_1^0, b_2^0, b_3^0, b_4^0, b_5^0, b_6^0, b_7^0, b_8^0, b_9^0\} \quad (8)$$

where:  $b_1 = t$ ;  $b_2 = t$ ;  $b_3 = a$ ;  $b_4 = d$ ;  $b_5 = d$ ;  $b_6 = a$ ;  $b_7 = f$ ;  $b_8 = R$ ;  $b_9 = f$ .

Based on technical and scientific literature [10], as well as on the results of prior numerical experiments [13; 14; 1], the bounds of the possible variations of the components of the design parameter vector are determined.

The limiting values of the design parameter vector  $\{b\}$  obtained in accordance with the parametric constraints (values are given in the technical system of units):

$$\begin{aligned} 0,5 \geq b_1 \geq 0,9mm; \quad 20 \geq b_2 \geq 10cm; \quad 100 \geq b_3 \geq 300cm; \quad 0 \geq b_4 \geq 20cm; \\ 0,8 \geq b_5 \geq 1,6cm; \quad 10 \geq b_6 \geq 20cm; \quad 8,5 \geq b_7 \geq 19,5MPa; \\ 200 \geq b_8 \geq 400MPa; \quad 225 \geq b_9 \geq 435MPa; \\ 200 \geq b_8 \geq 400MPa; \quad 225 \geq b_9 \geq 435MPa; \end{aligned} \quad (9)$$

Once the parametric constraints have been determined, the corresponding values of can be established:  $b_i, \delta b_i, i=1,5$ , using uniform interval partitioning (in the Cartesian coordinate system  $oz'z''z'''$ ):

$$\{b_i^0\} = \{0,5; 20,0; 300,0; 20,0; 0,8; 10; 8,5; 200,0; 225,0\}; \quad (10)$$

$$\{\delta b_i^0\} = \{0,1; 2,0; 5,0; 4,0; 0,2; 2,0; 3,0; 50,0; 70,0\}. \quad (11)$$

After getting the values  $\{b_i^0\}$ ,  $\{\delta b_i^0\}$  calculate the objective function at the base point  $f^0(b^0, u^0)$ . That is, the system of equations (2) is solved, taking into account the strength constraints. Next, one of the main stages of the direct search—the exploratory search—is initiated, as indicated in the block diagram by sequence “2” [28]. At this stage, each variable is varied cyclically  $b_i$  each time only one variable is changed while the others are considered constant, by the selected increment values, until all parameters  $\{b\}$  have been updated. For example,  $b_i^{(0)}$  is changed by an increment  $\delta b_i^{(0)}$  such that:

$$b_i^{(1)} = b_i^{(0)} + \delta b_i^{(0)} \quad (12)$$

If such an increase does not improve (does not decrease) the objective function (1), the  $b_i^{(0)}$

changes to  $\delta b_i^{(0)}$  and meaning  $f^1(b,u)$  checked as before.

If the value  $f^1(b,u)$  does not improve no  $b_i^{(0)} + \delta b_i^{(0)}$ , no  $b_i^{(0)} - \delta b_i^{(0)}$ , then  $b_i^{(0)}$  leave unchanged. Then  $b_i^{(0)}$  change by a value  $\delta b_2^{(0)}$  and so on until all independent variables have been changed, which means completing one exploratory search [15; 18]. Obtaining each value of the objective function  $f^t(b^t, u^t)$  on the next promotion on the independent variable  $\{b^t\}$  and constitutes the solution to the problem of non-linear deformation of the floor structure. At the same time, the value compared to the solution  $f^t(b^t, u^t)$  at the previous point. If, as a result of the next solution of the problem, the objective function (1) improves at a given step, then its previous value is replaced by a new one during further comparison. In case of a disturbance on  $\{b^t\}$  is unsuccessful, the previous value is retained  $f^{t-1}(b^{t-1}, u^{t-1})$ .

After conducting one (or more) successful research searches according to the procedure of algorithm 2-3 (Fig. 3), the transition to the second stage of optimal search "4" is carried out – the search strategy by sample [4; 11; 25]. Successful variable changes  $b_i^t$  in the research search ((i.e. changing variables  $b_{i-1}^t$ , that reduced  $f^t(b^t, u^t)$ ), define a vector in the space of design variables  $B$ , which indicates a certain direction of minimization that can best contribute to success, a vector  $B = b_k$ ,  $k \leq i$ .

A pattern search, or series of accelerating steps, is performed along this vector until it decreases  $f^t(b^t, u^t)$  (substantially, by a certain nominal amount) during each of these searches. Step length when searching for a pattern in a specific coordinate direction  $b_k^t$  is approximately proportional to the number of successful steps previously taken in this coordinate direction during exploration searches over several previous cycles. To speed up the optimization process, changing the step size  $\delta b_k^t$  in pattern search is carried out by entering a given multiplier at the value  $\delta b_k^t$  in research searches [10].

## CONCLUSIONS

An exploration search performed after a pattern search is called a Type II exploration search, which determines the success or failure of the search for a given pattern. If  $f^t(b^t, u^t)$  does not decrease in the process of exploratory search of type II, it is considered that this search by sample is unsuccessful, then transition 5-2 is performed (block diagram in Fig. 3.) and a new exploratory search of type I is performed to determine the coordinate vector of a new, more successful direction. If the exploratory search of

type I does not yield a new successful direction, then successively reduce  $\delta b_i^t$ , until it becomes possible to determine a new successful direction or  $\delta b_i^t$  will not fall below certain predetermined permissible values.

Inability to reduce  $f^t(b^t, u^t)$ , when the value  $\delta b_i^{t-1}$  is sufficiently small, indicating that a local optimum has been reached. The above sequence of direct Hooke-Jeeves search is considered complete if the conditions of the three main tests are satisfied, i.e. solutions to the sought problem with changed components  $\delta b_{i-1}^t$ .

The first test is conducted after each exploratory search and pattern search, during which the change in the objective function value must exceed a specified threshold; otherwise, the search is considered unsuccessful.

The second test is conducted after failure in the exploratory search at the change reduction stage  $\delta b_i^t$ . The search can be completed if at this step the change in each variable  $\delta b_i^t$ . If it is found to be less than a predetermined threshold, a third test is performed after the completion of the search algorithm, as shown in the block diagram (Fig. 3). This test involves an analysis of the state variables, i.e., an assessment of the quality of the stress-strain state resulting from the satisfaction of constraint (3): whether there are zones of plastic deformation (even in a single finite element), or whether they are absent. If local zones of plastic deformation are present, the bounds of the components of the design variable vector are adjusted, for example, a new more ductile steel grade may be introduced, or the  $\{b_i^0\}$ .

This paper aims to establish a conceptual framework for subsequent sensitivity analyses of composite steel-concrete slabs regarding variations in nine critical design parameters. The current study focuses on the initial ('zero') stage of the research, aligned with the general methodology presented in the flowchart (Fig. 3).

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## АНОТАЦІЯ

### **Пономарьов П., Костира Н. Розв'язок задачі оптимального проектування робочої вежі елеватора при динамічних навантаженнях**

**Мета.** Метою роботи є розроблення та обґрунтування підходу до оптимального проектування сталезалізобетонних перекриттів робочих веж елеваторів, що зазнають дії динамічних навантажень від зерноочисних машин. Дослідження спрямоване на формування математичної моделі задачі оптимізації, визначення системи узагальнених параметрів проектування та розроблення методики їх раціонального вибору з урахуванням обмежень за міцністю та експлуатаційною придатністю. Особливу увагу приділено застосуванню методу прямого пошуку Хука–Дживса у поєднанні з принципами розрахунку за граничними станами для оптимізації основних конструктивних параметрів, зокрема товщини плити, кроку балок перекриття, характеристик анкерних з'єднань та схеми армування. Також у дослідженні враховано вплив динамічних навантажень, що виникають при різних режимах роботи сепараторних машин, у загальній розрахунковій схемі сталезалізобетонних перекриттів.

**Методологія.** Дослідження ґрунтується на комбінованому підході, що поєднує розрахунки за граничними станами з методом прямого пошуку Хука–Дживса для оптимізації конструктивної схеми сталезалізобетонних перекриттів. Сформовано математичну модель задачі оптимізації, яка включає цільову функцію, засновану на згинальних напруженнях, а також систему обмежень у вигляді нелінійних рівнянь рівноваги, умов міцності та допустимих діапазонів параметрів проектування. До множини узагальнених змінних проектування віднесено товщину плити, крок балок перекриття, діаметр анкерних з'єднувачів та характеристики армування, тоді як основні геометричні параметри конструкції розглядаються як фіксовані вихідні дані.

Процедура оптимізації передбачає ітераційне варіювання окремих параметрів з подальшою оцінкою реакції конструкції за дії комбінованих постійних, змінних і динамічних навантажень, що генеруються зерноочисними машинами в різних режимах роботи.

**Результати.** Застосування запропонованої методики оптимізації дозволило сформулювати впорядковану процедуру визначення раціональних параметрів сталезалізобетонних перекриттів робочих веж елеваторів. Визначено базову точку процесу оптимізації, а також встановлено допустимі межі варіювання основних параметрів проектування, зокрема товщини плити, кроку балок перекриття, діаметра анкерних з'єднувачів та характеристик армування.

**Наукова новизна.** Наукова новизна дослідження полягає у розробленні комплексного підходу до оптимального проектування сталезалізобетонних перекриттів робочих веж елеваторів, який поєднує принципи розрахунку за граничними станами з методом прямого пошуку Хука–Дживса. Відмінною особливістю запропонованого підходу є явне врахування динамічних навантажень, що генеруються зерноочисними машинами у різних режимах роботи, які інтегруються в процес оптимізації. Це забезпечує більш точне відображення реальних умов експлуатації порівняно з традиційними методами статичного розрахунку. Крім того, у роботі сформовано впорядковану процедуру варіювання параметрів і визначення напрямку пошуку в просторі проектування, що створює основу для подальшого розвитку методів оптимізації сталезалізобетонних конструкцій.

**Практична значущість.** Запропонований підхід може бути застосований при проектуванні сталезалізобетонних перекриттів робочих веж елеваторів та аналогічних промислових споруд, що зазнають дії динамічних навантажень від технологічного обладнання. Розроблена методика надає інженерам системний інструмент для вибору раціональних параметрів проектування, зокрема товщини плити, кроку балок, характеристик анкерних з'єднувачів та схеми армування, з урахуванням вимог міцності та експлуатаційної придатності. Її впровадження забезпечує більш достовірне врахування динамічних впливів на стадії проектування, що сприяє підвищенню надійності, довговічності та ефективності експлуатації конструкцій. Запропонований підхід може бути інтегрований у сучасну інженерну практику та адаптований для використання в середовищах чисельного моделювання, що дозволяє підвищити ефективність прийняття проектних рішень при створенні та модернізації об'єктів зернопереробної інфраструктури.

**Ключові слова:** сталезалізобетонні перекриття, робочі вежі елеваторів, динамічні навантаження, зерноочисні машини, оптимізація конструкцій, метод Хука–Дживса, проектування плит, зниження вібрацій.

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