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ASSESSING ACHIEVED SAVINGS USING OPTIMIZED TRUSSES WITH CARDINALITY CONSTRAINTS

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Abstract: *This research presents the additional benefits gained when using cardinality constraints in just sizing and combined sizing and shape optimization to find solutions with minimal weight while using a set number of different cross-sections allowed in the design. When limiting the number of cross-sections, an optimal solution can result in a structure with a reasonable number of different types of stock needed, unlike an approach which is unconstrained in this regard. This creates a more practical solution, which reduces the complexity of the solution and more resembles an experience-driven design, but with a lower overall weight than analytical solutions due to the optimization methods' ability to explore practically the entire search space for a minimal weight solution. This limitation has adverse effects on the design. The downside is that the weight of the resulting structure is higher than the global optimum (one which disregards the number of different types or sizes of cross-sections used). However, it means that there are fewer different bar stock dimensions to be ordered, and less waste is created once the necessary pieces are cut from standard bar stock. The example used for these purposes is a typical optimization problem of a 17-bar truss with various numbers of different cross-sections used. The optimal solutions for this example were made using original software developed by the authors for the purposes of previously published research. Standard, available, bar stock dimensions were used in the optimization process in order to best resemble a real-world application. The results illustrate the added benefits of including fewer different bar stock types and the accompanying savings, which are indirectly created using this method.*

Keywords: *truss; optimization; sizing; shape; cardinality constraint.*

1. INTRODUCTION

Recent advancements in structural optimization have been largely driven by improvements in algorithmic speed and capability. This trend is particularly evident in the field of structural truss optimization, where researchers have extensively applied both new and modified algorithms to standard benchmark problems. While such problems are valuable for comparing performance metrics, they often fall short in addressing the practical applicability of the solutions in real-world scenarios. The introduction of heuristic methods initially brought significant improvements, but since then, progress has been more gradual, focused mainly on enhancing convergence speed and fine-tuning specific algorithm parameters.

Researchers in [1] proposed an enhanced version of the Grey Wolf Optimization algorithm (EGWO) to address its limitations in exploration and susceptibility to local optima. They improved the algorithm using gamma, z-position, and the golden ratio, then evaluated its performance on benchmark functions and two real-world engineering problems, demonstrating superior results compared to several other metaheuristic algorithms. [2] proposed several optimization models for both continuous and discrete truss design problems, incorporating constraints such as Euler buckling, Hooke's law, and limits on stress and displacement. Their approach significantly outperforms traditional MILO solvers in both speed and solution quality, achieving up to 66%

weight reduction and solving previously intractable large-scale truss design problems. Serdar Avcı et al. applied the Improved Stochastic Ranking Evolution Strategy (ISRES) algorithm in [3] to the sizing and layout optimization of various truss benchmark structures, aiming to minimize weight while satisfying stress and displacement constraints. They tested the algorithm on multiple configurations, validated the optimized designs using finite element analysis, and compared its performance with other methods. The results showed that ISRES is both efficient and robust, making it a practical and reliable tool for complex structural optimization problems in engineering applications.

Building on this trend, more recent studies have shifted their focus toward handling increasingly realistic constraints, such as those arising from buckling behaviour, which greatly influence the structural integrity and practicality of optimized designs. Dynamic buckling constraints have become increasingly common in truss optimization due to their significant impact on problem complexity, introducing nonlinear and non-convex solution spaces. Evolutionary algorithms have enabled researchers to tackle these challenges effectively by avoiding local optima. However, many studies, such as [4], continue to use fixed values for buckling constraints, which do not guarantee minimal weight or practical applicability. A comparison in [5] demonstrated a substantial increase in optimal weight when Euler buckling constraints were applied, due to the need for larger cross-sections in compression members. In [6], the authors used dynamic buckling constraints to achieve better weight minimization, showing improvement over the results presented in [7] for various benchmark examples. The PO (Political Optimization) algorithm introduced in [8] successfully addressed standard test problems with buckling constraints, though it relied on continuous sizing variables, limiting its real-world applicability. More recently, researchers in [9] developed an iterative algorithm for truss size optimization that incorporates stress, displacement, and local buckling constraints, particularly addressing the added complexity introduced by dynamic buckling conditions.

In parallel with these developments, efforts have also been made to incorporate additional constraints aimed at enhancing practical applicability—particularly those related to limiting the number of distinct cross-sections used in optimized trusses. Researchers in [10] explored the practical implications of introducing a constraint on the number of different cross-sections used in truss sizing optimization. By applying this constraint to four benchmark problems, under dynamic Euler buckling conditions and discrete cross-section sets, the study analyses how limiting cross-section variety affects solution quality. The paper [11] investigates the impact of applying cardinality constraints to limit the number of distinct cross-sections in simultaneous sizing and shape optimization of truss structures. Standard benchmark examples are used to compare solutions with varying cardinality limits against both unconstrained optimal solutions and single cross-section cases. The results are also compared to earlier research focused solely on sizing optimization under the same constraints.

This paper investigates the additional savings that can be achieved by imposing cardinality constraints on truss sizing and combined sizing and shape optimization, focusing on how limiting the number of different cross-sections can offset the weight savings typically achieved through other optimization methods. By examining a typical 17-bar truss, the research demonstrates that while the optimal weight solutions with fewer cross-sections may not match the global optimum, they offer significant practical advantages, such as reduced material waste and simplified construction. The results reveal that limiting cross-section types can lead to lower material requirements when considering both weight reduction and the reduction of offcuts, offering a more practical solution for real-world applications.

2. THE 17-BAR TRUSS

The 17-bar truss example is made from construction steel with a Young modulus of 21000 MPa and a density of 7400 kg/m^3 [10, 11]. A load of F =444.82 kN is applied to node (9) as is shown in Fig.1. The chosen set of cross-sections comprises 49 distinct diameters, ranging from 3 mm to 125 mm, as follows: 6, 8, 12, 12, 14, 15, 16, 17, 18, 20, 22, 24, 25, 28, 30, 32, 35, 36, 38, 40, 45, 50, 55, 56, 60, 63, 65, 70, 75, 80, 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 140, 150, 160, 170, 180, 190, 200, 220, and 250 mm. Displacement is constrained to ±0.0508m for all nodes in both directions, and Euler buckling constraints are used for all compressed bars.

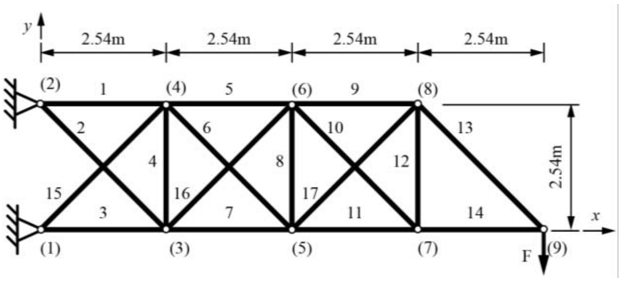


Fig.1. The 17-bar truss layout [11]

Coordinates for nodes (3-8) can take any position from 0 to 10.16 m in the x and from -2.54 to 5.08 m in the y-direction with from their initial configuration. The y-component of the node (9) coordinates is the only one that can vary from 0 to 2.54 m from its initial configuration.

The resulting weights for sizing optimization (S) and sizing and shape (S+S) optimization, as per [10] and [11], respectively, are presented in Table 1. In this table, results for each optimization type are shown with cardinality values from one to three, as well as the global optimum with the corresponding number of different cross-sections used when cardinality constraints are not applied.

Table 1. Optimal weights of solutions from literature.

Solution	Weight [kg]	Solution	Weight [kg]
S 1	3181.777	S+S 1	2720.745
S 2	2047.368	S+S 2	1647.07
S 3	1836.005	S+S 3	1471.678
S 8	1571.875	S+S 6	1355.876

Fig. 2 shows the difference from the solution with a single cross-section for the given solution type. Table 2 shows the coordinates of nodes in the optimal configurations for the sizing and shape-optimized solutions from [10, 11].

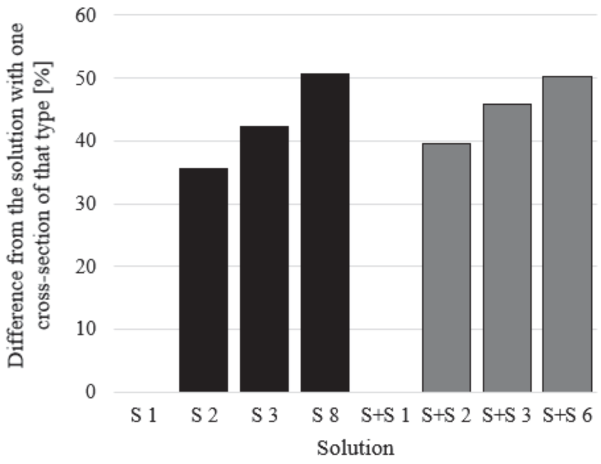


Fig.2. difference from the solution with a single cross-section for the given solution type.

Table 2. Optimal coordinates of points according to the number of different cross-sections used for the 17-bar truss example [11].

Coordinate [m]	S+S1	S+S2	S+S3	S+S6
x_3	2.652	2.722	2.741	2.651
y_3	0.123	-0.247	-0.269	-0.303
x_4	3.12	1.524	1.532	1.604
y_4	2.125	2.498	2.436	2.411
x_5	5.192	5.676	4.99	5.45
y_5	0.373	-0.136	-0.285	-0.272
x_6	5.184	3.993	4.029	4.068
y_6	1.881	1.833	2.194	2.356
x_7	6.665	6.949	7.699	8.16
y_7	0.296	-0.144	-0.445	-0.205
x_8	6.649	6.385	7.085	7.766
y_8	1.917	1.338	1.927	1.909
y_9	0.828	0.343	0.718	0.584

3. ANALYSIS OF RESULTS

The optimal results taken from literature, which were presented in the previous heading, have been compared according to various criteria. The first step was to determine which cross-sections were used for which bar and to group the same profiles in each of the eight analysed trusses. For easier visual tracking of results, a color-coding system was implemented, which is the same for all trusses, in the sense that from largest to smallest, the colours are in the same order, but the colours do not necessarily correspond to the same cross-section diameter across all trusses. This color-coding system is the same for all subsequent figures and corresponds to the colour scheme shown in Table 3.

This table shows the bar cross-section diameter and corresponding colour for each of the eight solutions. Table 4 presents the lengths of each of the bars for all of the solutions. Since the sizing-optimized solutions all have the same initial layout, the lengths of bars for all those solutions are the same.

Table 3. Bar cross-section diameter according to solution

	Bar cross-section diameter for given solution [mm]							
Bar no.	**S 1**	**S 2**	**S 3**	**S 8**	**S+S 1**	**S+S 2**	**S+S 3**	**S+S 6**
1	105	75	75	75	105	105	85	85
2	105	75	75	55	105	22	45	50
3	105	105	105	105	105	105	105	105
4	105	75	75	8	105	22	45	50
5	105	75	75	85	105	105	85	85
6	105	75	75	55	105	22	45	50
7	105	105	105	105	105	105	105	100
8	105	75	75	6	105	22	45	25
9	105	105	75	70	105	105	85	75
10	105	75	75	70	105	22	45	25
11	105	105	85	85	105	105	85	85
12	105	75	75	70	105	22	45	25
13	105	75	75	70	105	105	45	50
14	105	75	75	75	105	105	85	75
15	105	75	75	80	105	105	85	75
16	105	75	75	85	105	22	85	75
17	105	105	85	80	105	105	85	85

Corresponding to the colours of the cells in Table 3, Figures 3 and 4 give a visual representation of the locations of each cross-section on the optimal structures for sizing-optimized solutions in Fig. 3 and sizing and shape-optimized solutions in Fig 4.

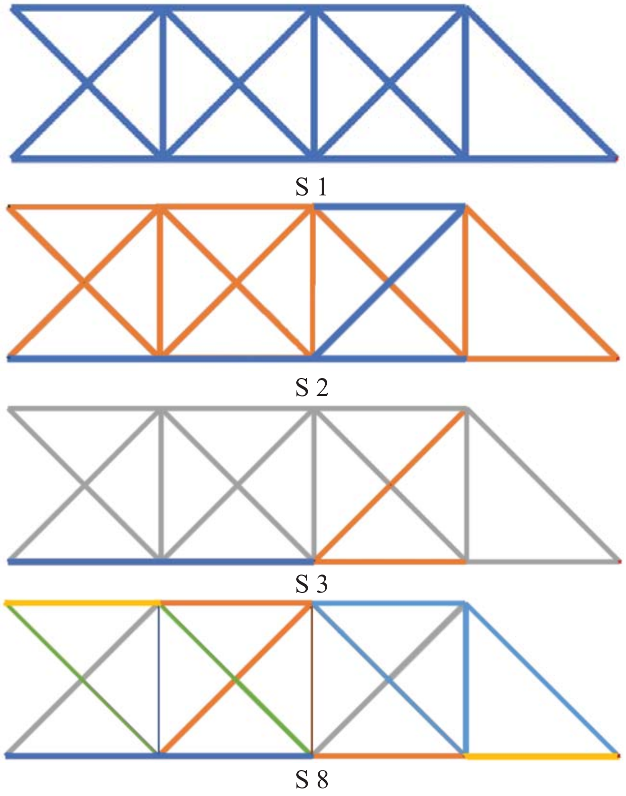
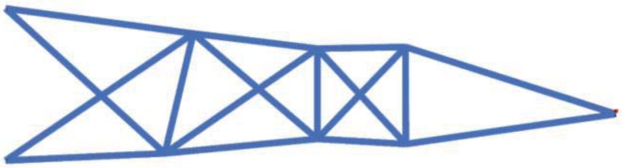


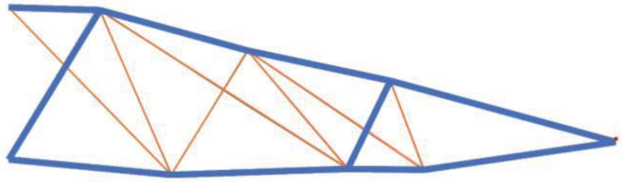
Fig.3. Cross-section configuration layout corresponding to Table 3 for sizing optimization

Table 4. Bar lengths for each of the observed solutions

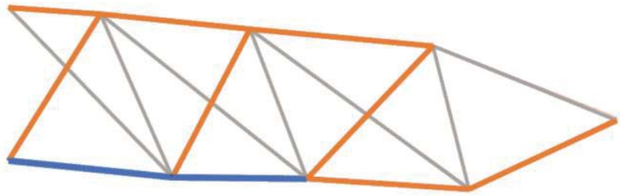
	Bar lengths for given solution [m]				
Bar no.	**S 1, S 2, S 3 and S 8**	**S+S 1**	**S+S 2**	**S+S 3**	**S+S 6**
1	2.540	3.147	1.525	1.536	1.609
2	3.592	3.588	3.896	3.925	3.887
3	2.540	2.655	2.733	2.754	2.668
4	2.540	2.056	2.995	2.963	2.909
5	2.540	2.078	2.557	2.509	2.465
6	3.592	2.713	4.917	4.400	4.689
7	2.540	2.552	2.956	2.249	2.799
8	2.540	1.508	2.590	2.659	2.969
9	2.540	1.465	2.443	3.068	3.725
10	3.592	2.169	3.556	4.520	4.827
11	2.540	1.475	1.273	2.714	2.711
12	2.540	1.621	1.586	2.450	2.150
13	3.592	3.676	3.904	3.304	2.736
14	2.540	3.535	3.248	2.722	2.150
15	3.592	3.775	2.926	2.878	2.896
16	3.592	3.082	2.438	2.779	3.013
17	3.592	2.123	1.636	3.047	3.181



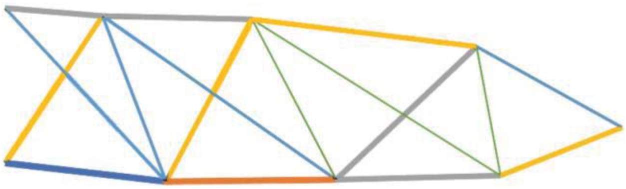
S+S 1



S+S 2



S+S 3



S+S 8

Fig.4. Cross-section configuration layout corresponding to Table 3 for sizing and shape optimization

Fig. 5 shows the distribution of the lengths of each of the cross-sections for all of the optimal solutions following the same colour-coding scheme as Table 3.

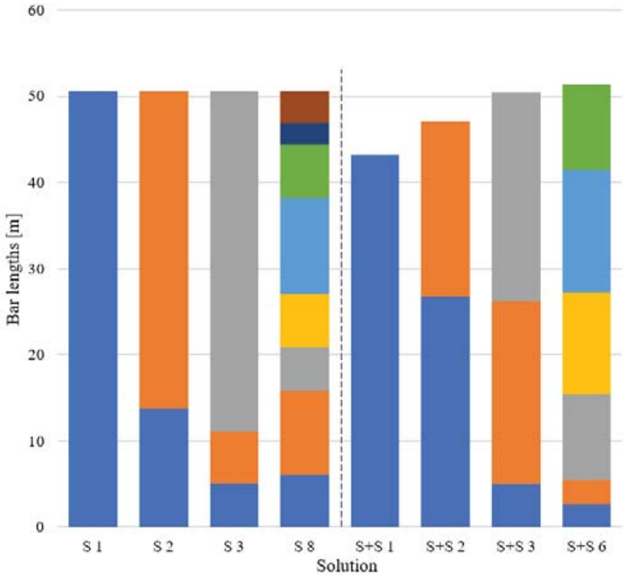


Fig.5. Lengths of bars by cross-section for each of the solutions.

Figure 6 shows the number of pieces of 6m bar stocks which need to be acquired for each of the different cross-sections used in each of the solutions. These numbers are calculated by dividing the total length of each type of bar needed, and then those values are rounded up to obtain whole numbers of bar stocks. This is done as a rough estimate of the necessary material needed since, for these types of structures, bars are most commonly extended by welding to minimize waste.

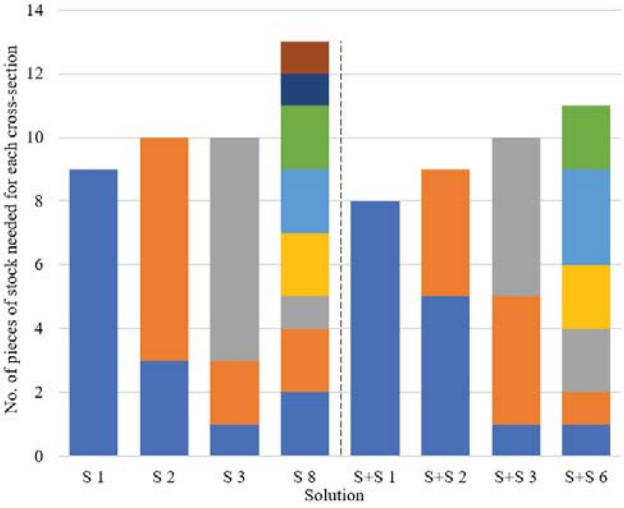


Fig.6. Number of pieces of 6m bar stocks needed of each of the different cross-sections used in each of the solutions.

Since the total length of acquired material needs to be cut to size, there will inevitably be wasted material after cutting, which results in off-cuts which are scrapped. The length of these off-cuts is calculated by taking the total length of the number of each cross-section stock (shown in Fig. 5) and subtracting the total used length (shown in Fig. 6) for that cross-section (shown in Fig.7).

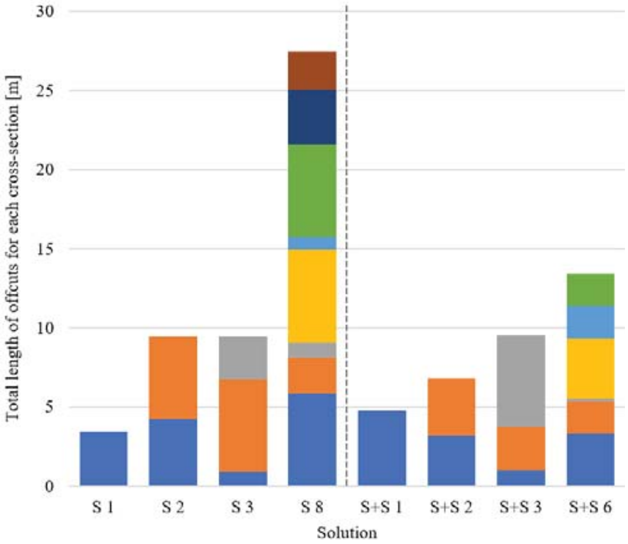


Fig.7. Total lengths of offcuts for each cross-section of each of the solutions.

Fig. 8 shows the overall weight used for each of the solutions.

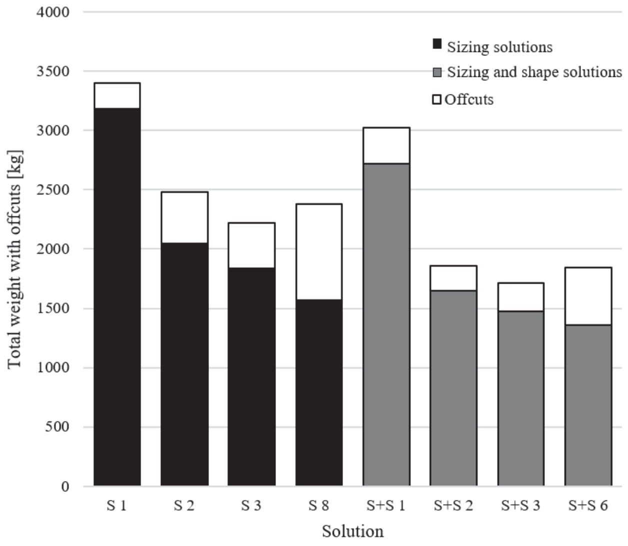


Fig.8. Overall weight of material used.

4. CONCLUSION

This research considered possible added benefits of using optimal solutions limited by cardinality constraints in order to further demonstrate the benefits of using such limits in optimization. These limitations are more in line with actual trusses found in practice and present a more feasible solution to those that do not take into account the total number of different cross-section types that need to be used to achieve the optimal, minimal weight.

In order to have the results comparable to other solutions found in literature, a typical 17-bar truss example was examined. Results from papers where the cardinality constraint was implemented were used in order to analyse the benefits of using such solutions, compared to those which do not consider this constraint. Sizing (S) and combined sizing and shape (S+S) optimization results were considered. The analysed parameters were the total lengths of each of the cross-section diameters, the number of whole pieces of 6m bar stock needed to cut and extend in order to achieve all those lengths, and the lengths of offcuts for each type of stock.

Since the sizing-optimized solutions do not vary the locations of the connection nodes, the total length of the total numbers of bars for each solution is the same. The decrease in weight compared to the single-cross-section solution (S 1) for the two and three different cross-sections solutions are 35.653% and 42.296%, respectively. Compared to the global optimum, which doesn't include the cardinality constraint in sizing optimization (S 8), which is ~50% of the weight of the S 1 solution, the S 3 solution is the better choice since the total weight with offcuts is lower than the S 8 solution.

It should be noted that solutions S 1 and S+S 1 use the same cross-section, and from the graph, it is obvious that the main savings in weight that can be made when using only one cross-section, in this case, is basically just shape optimization. This decrease in length of ~7m correlates directly with a reduction of ~461kg, or ~14.5% of both length and weight.

The sizing and shape optimized solutions (S+S) show a similar trend to the sizing solutions. Though out of the four observed S+S solutions, S+S 2 has the least amount of discarded material, the S+S 3 solution, with only ~30kg more of waste, has a lower overall weight compared to the S+S 2 solution by ~145kg.

It is evident from the presented analysis that when considering wasted material from bar stock, the minimal construction weight solution is not the minimal total material required solution. It should also be considered that the offcut material isn't necessarily directly wasted as it can be used in other, subsequent structures and that the number of repetitions of the same construction would influence the amount of wasted material. Still, for this research, only a single construction was considered. If multiple constructions of the same design are needed, then this analysis could be used as a basis for selecting the optimal solution in that case as well, just with the added consideration of multiplying the number of element lengths used by the number of construction instances. Cutting plans can be further optimized or included in a new multi-objective optimization process as an additional way to ensure savings.

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REFERENCES

[1] Mohammed, H., Abdul, Z. and Hamad, Z.: Enhancement of GWO for solving numerical functions and engineering problems. *Neural Computing and Applications*, Vol.36, No.7, pp. 3405-3413, ISSN 0941-0643, 2023

[2] Shahabsafa, M., Mohammad-Nezhad, A., Terlaky, T., Zuluaga, L., He, S., Hwang, J. T. and Martins, J. R. R. A.: A novel approach to discrete truss design

problems using mixed integer neighborhood search. *Structural and Multidisciplinary Optimization*, Vol.58, No.6, pp. 2411-2429, ISSN 1615-1488, 2018

[3] Avcı, M. S., Yavuz, D., Ercan, E. and Nuhoğlu, A.: Efficient Sizing and Layout Optimization of Truss Benchmark Structures Using ISRES Algorithm. *Applied Sciences*, Vol.14, No.8, pp. 3324, ISSN 2076-3417, 2024

[4] Pham, H.-A. and Tran, T.-D.: Optimal truss sizing by modified Rao algorithm combined with feasible boundary search method. *Expert Systems with Applications*, Vol.191, pp. 116337, ISSN 09574174, 2022

[5] Petrović, N., Kostić, N., Marjanović, N. and Marjanović, V.: Influence of Using Discrete Cross-Section Variables for All Types of Truss Structural Optimization with Dynamic Constraints for Buckling. *Applied Engineering Letters*, Vol.3, No.2, pp. 78-83, ISSN 2466-4677, 2018

[6] Artar, M. and Carbas, S.: Discrete sizing design of steel truss bridges through teaching-learning-based and biogeography-based optimization algorithms involving dynamic constraints. *Structures*, Vol.34, pp. 3533-3547, ISSN 23520124, 2021

[7] Hasançebi, O., Çarbaş, S., Doğan, E., Erdal, F. and Saka, M. P.: Performance evaluation of metaheuristic search techniques in the optimum design of real size pin jointed structures. *Computers & Structures*, Vol.87, No.5-6, pp. 284-302, ISSN 00457949, 2009

[8] Awad, R.: Sizing optimization of truss structures using the political optimizer (PO) algorithm. *Structures*, Vol.33, pp. 4871-4894, ISSN 23520124, 2021

[9] Bich Quyen, V. T., Khanh, C. Q., Thuy Van, T. T., Khoa, D. N. and Truc, T. P.: A New Algorithm for Size Optimization of the Truss Structures with Buckling Constraint using Finite Element Method. *IOP Conference Series: Materials Science and Engineering*, Vol.661, pp. 012041, ISSN 1757-899X, 2019

[10] Petrović, N., Marjanović, V., Kostić, N., Marjanović, N. and Viorel Dragoi, M.: Means and Effects of Constraining the Number of Used Cross-Sections in Truss Sizing Optimization. *Transactions of FAMENA*, Vol.44, No.3, pp. ISSN 13331124, 2020

[11] Kostic, N., Petrovic, N., Marjanovic, V., Nikolic, R. R., Szmidla, J., Marjanovic, N. and Ulewicz, R.: Effects of Limiting the Number of Different Cross-Sections Used in Statically Loaded Truss Sizing and Shape Optimization. *Materials (Basel)*, Vol.17, No.6, pp. ISSN 1996-1944, 2024