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AHP Method Application for Ribbon Pontoon Bridges Evaluation

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Abstract

The construction of water crossings constitutes one of the fundamental tasks of military engineering units. Under combat conditions, such operations are frequently required to be executed within timelines measured in hours. This tempo is enabled by ribbon pontoon bridge systems. Four main structural design concepts can be distinguished among these systems. This paper presents the results of an Analytic Hierarchy Process (AHP) analysis applied to the problem of selecting among this four design concepts, taking into account two distinct profiles of water obstacles.

KEY WORDS: *decision support, pontoon ribbon bridge; Analytic Hierarchy Process (AHP); multi-criteria decision-making technique*

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1. Introduction

During military operations, a critical factor determining mission success is the ability to ensure maneuverability of friendly forces. This, in turn, requires maintaining the continuity and throughput of lines of communication. Recognizing this, an adversary will attempt to disrupt key elements of transportation infrastructure. Priority targets are typically those components that channel movement and thus determine the capacity of a given route. Bridges constitute a primary example of such critical infrastructure.

To mitigate the adverse effects of such actions, armed forces must possess the capability to rapidly establish crossings over water obstacles. Time is a decisive factor in this context; however, the load-bearing capacity of the bridge is of equal importance. It is generally required that such structures enable the crossing of main battle tanks. In their case, the engineering challenge arises not only from their substantial mass but also from the relatively short track contact length. The combination of these factors results in high contact pressures and, consequently, significant loads that must be transferred by the bridge structure. This directly translates into demanding strength requirements imposed on both the deck and the supporting elements.

From the standpoint of construction tempo, the latter component—supports—is of particular significance. In structures employing conventional fixed supports, numerous factors determine both their structural characteristics and construction methodology. Among these, the composition and bearing capacity of the riverbed play a ial role. Achieving a high rate of bridge construction requires independence from such environmental constraints. This can be accomplished through the use of floating support systems.

Such solutions are widely employed in military engineering and are known as ribbon-type pontoon bridges. These systems enable the construction of a 100 m crossing in less than 30 minutes, significantly outperforming other bridge types in terms of deployment speed. However, despite this advantage, such solutions exhibit limitations that restrict their application in the civilian sector. Nevertheless, pontoon bridge systems of this type are in service with the armed forces of numerous countries. Their introduction dates back to the early 1970s.

Initially, these systems were developed as bespoke solutions tailored to the requirements of individual armed forces and produced using domestic industrial capabilities. Examples include the Polish PP-64 (Fig. 1) and the Russian PMP series, culminating in the PP-2005 (Fig. 2). In contrast, some systems have been developed as standardized solutions intended for a broader range of users, resulting in less specialized designs. Examples include the U.S. Improved Ribbon Bridge (IRB) (Fig. 3) and the French Pont Flottant Motorisé (PFM) (Fig. 4).

Despite sharing the same underlying structural concept, these bridge systems differ in specific tactical and technical parameters. These differences arise from design assumptions, which in turn reflect the environmental conditions anticipated during their operational use. This leads to the question of how particular design solutions align with the needs of a prospective user who seeks to acquire such a system but was not involved in defining its original operational requirements. This paper addresses this issue through the application of the Analytic Hierarchy Process (AHP), a multi-criteria decision-making method designed to support complex selection processes.

2. Materials

For the purposes of the conducted AHP analysis, two profiles of operational requirements for prospective users of ribbon pontoon bridge systems were defined. The first profile represents a state operating primarily in an environment dominated by regulated rivers. This is reflected in the following characteristics:

- a river depth at the shoreline exceeds 1.5 m;
- current velocity does not exceed 2 m/s;
- river depth generally remains above 1.5 m;
- most potential crossing sites offer limited space for vehicles and personnel involved in bridge construction;
- a significant proportion of crossing traffic consists of track vehicles up to class MLC 30T (Military Load Classification) [15,17].

The second profile represents a state operating primarily in regions characterized by unregulated rivers. This translates into the following conditions:

- a river depth of approximately 1.5 m is reached at a distance of about 5 m from the shoreline;
- seasonal fluctuations in water levels may result in localized shallows with depths below 0,8 m;
- most potential crossing sites provide ample space for vehicles and personnel, enabling maximum construction tempo;
- the majority of crossing traffic consists of track vehicles exceeding class MLC 30T.

Both user profiles require bridge systems capable of supporting the crossing of main battle tanks with load classifications up to MLC 70T. Each user evaluates four structural concepts corresponding to specific fielded systems:

a) the Polish PP-64 pontoon bridge set Fig. 1;
b) the French Motorized Floating Bridge (PFM) Fig. 2;
c) the U.S. Improved Ribbon Bridge (IRB) - Fig. 3;
d) the Russian PP-2005 pontoon bridge set - Fig. 4.

Selected tactical and technical parameters of these systems are presented in Table 1. In their single-ribbon configuration, both the Polish and Russian systems do not meet the required MLC classification for tank crossings. However, both designs allow for multi-bay (enhanced ribbon) configurations, which increase their load-carrying capacity. Taking advantage of this structural feature, the analysis assumes the PP-64 in a double-ribbon configuration and the PP-2005 in a one-and-a-half ribbon configuration.

Fig.1. Polish ribbon pontoon bridge PP-64 [10]

Fig.2. French ribbon pontoon PFM [11]

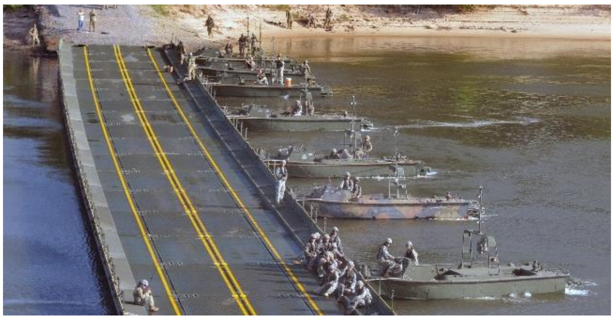

Fig.3. U.S. ribbon pontoon bridge IRB [12]

Fig.4. Russian ribbon pontoon bridge PP-2005 [13]

Table 1

Selected tactical and technical parameters of the analyzed ribbon pontoon bridges [6,14,16]

Parameter name and unit	PP-64 (2 ribbons)	PFM (1 ribbon)	IRB (1 ribbon)	PP-2005 (1,5 ribbons)
Country of production	Poland	France	USA	Russia
Width of the bridge	12,5	9,8	8,4	11,4
Lane width, m	4,35	4,0	4,50	4,50
Pontoon block weight, kg	3 600	10 500	6350	8 550
Width with the vehicle, m	2,5	3,60	3,60	3,35
Length with the vehicle, m	9,0	18,0	11,7	10,7
Height with the vehicle, m	3,4	4,0	4,0	3,7
MLC class of the transport vehicle.	12W	25W	28W	25 W
Bridge load capacity in MLC (Wheel/ Track)	80W/80T	80W/70T	96W/80T	99T
Bearing capacity of 2 lines	2 x 40W	-	2 x 20W	2 x 30W
Bridge throughput for MLC 70T, vehicles/hour*	250	210	240	360
Bridge throughput for MLC 30 T, vehicles/hour*	580	410	370	800
Permissible speed of the current, m/s	2,9	2,0	2,1	3,25*
Resistance to wind, °B	1	1	1	3*
Minimum launching depth, m	1,0	1,5	1,1	1,2
Minimum operating depths, m	1,5	1,2	1,1	1,5
Draft own / loaded, m	0,17/0,70	0,17/0,33	0,13/0,50	0,15/0,40*
Bank block / ramp length, m	4,0	12	6,7	6,7
Maximum height of the bank, m	1,0	3,0	2,2	2,2
Construction time (100 m bridge), min	45	20	30	45*
Number of vehicles	60	11	21	32*
Number of soldiers	126	42	65	98*

*parameter values estimated by the authors

3. Methods

In the AHP method applied to establish the ranking of the analyzed pontoon bridge systems, three principal stages of the algorithm can be distinguished:

I. Construction of pairwise comparison matrices for n alternatives within each criterion (matrices $A^{(1)}, A^{(2)}, \dots, A^{(K)}$), as well as for the criteria themselves (matrix $A^{(0)}$). This process results in K+1 pairwise comparison matrices ($A^{(0)}, A^{(1)}, A^{(2)}, \dots, A^{(K)}$). An important component of this stage is the assessment of the consistency of the decision-maker's judgments.

II. Determination of individual rankings derived from each matrix developed in Stage I.

III. Aggregation of results to obtain a multi-criteria ranking of the n alternatives.

However, prior to the implementation of Stage I, it is necessary to define the parameters to be compared. Their selection should reflect the primary needs of the end-user of the AHP analysis, that is, the key decision-making factors relevant to the specific operational context.

The outcomes of pairwise comparisons between decision elements are recorded in matrix form. In matrix $A^{(0)}$, the criteria are compared against one another, whereas in matrices ($A^{(0)}, A^{(1)}, A^{(2)}, \dots, A^{(K)}$), the alternatives are compared within each individual criterion. The comparisons are conducted using a nine-point qualitative scale translated into numerical values, as presented in Table 2.

The prioritization process for both criteria and alternatives is conducted in an identical manner and follows the scheme outlined below [3,4,7,8,9]:

1. For each parameter C_i, where $i=1, 2, \dots, n$, a comparison is made with parameter C_j where $j=1, 2, \dots, n$, to determine the relative importance of C_i over C_j. Based on this assessment, numerical values a_{ij} are assigned in accordance with the scale presented in Table 1. The results of these comparisons are recorded in the form of a square matrix. The matrix should satisfy the condition of consistency (transitivity):

$$a_{ij}^{(k)} = \frac{1}{a_{ij}^{(k)}} \ and \ a_{ii}^{(k)} = 1, (k = 0,1,2, \dots, K), \quad (1)$$

and exhibit consistency in the decision-maker's judgments:

$$a_{ij}^{(k)} = a_{ir}^{(k)} \times a_{rj}^{(k)}. \quad (2)$$

$$A = \begin{bmatrix} 1 & a_{12} & \dots & a_{1j} \\ \frac{1}{a_{12}} & 1 & \dots & a_{2j} \\ \dots & \dots & \dots & \dots \\ \frac{1}{a_{1j}} & \frac{1}{a_{2j}} & \dots & 1 \end{bmatrix}$$

2. Normalization of the matrix results:

$$\bar{a}_{ij}^{(k)} = \frac{a_{ij}^{(k)}}{\sum_{i=1}^{n} a_{ij}^{(k)}}. \quad (3)$$

3. Individual preference indices (local priorities):

$$s_i^{(k)} = \frac{\sum_{i=1}^{n} \bar{a}_{ij}^{(k)}}{n}. \quad (4)$$

The column vector $s^{(k)} = \left[s_i^{(k)}\right]$ is the individual ranking vector. The value of the index $s_i^{(k)}$ i indicates the position of object *i* in the individual ranking within the criterion *k*, i.e. the higher the value of the index $s_i^{(k)}$, the higher the position of object *i* within the given criterion.

Similarly for the pairwise comparison matrix for criteria A^0 alone. The value of the $s_i^{(0)}$ index indicates the position of criterion *i* in the individual ranking in relation to the remaining *K-1* criteria, i.e. the higher the value of the $s_i^{(0)}$ index, the more important the criterion is.

Similarly, for the pairwise comparison matrix of the criteria themselves A^0, the value of the index $s_i^{(0)}$indicates the position of criterion *i* in the individual ranking relative to the remaining *K−1* criteria; that is, the higher the value of the index $s_i^{(0)}$, the more important the criterion.

4. Determining the multi-criteria ranking - calculating the multi-criteria vector of preference indices $P=[p_i]$. The components of the vector P are calculated as follows:

$$p_i = \sum_{k=1}^{K} s_k^0 s_i^{(k)} \quad (5)$$

The value of the multi-criteria preference index indicates the position of object *i* in the multi-criteria ranking, i.e. the higher the value of the p_i index, the higher the position of object *i*.

Table 2

Scale of ratings used in pairwise comparisons of criteria and alternatives (Saaty's scale) [3,8,9]

Definition	Explanation	Intensity of importance
Equal importance	Two activities contribute equally to the objective	1
Moderate importance	Experience and judgment slightly favor one activity over another	3
Strong importance	Experience and judgment strongly favor one activity over another	5
Very strong importance	An activityis favored very strongly	7
Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation	9
Intermediate values for subtle differences	Only use when necessary (Weak importance, Moderate plus, Strong plus, Very,verystrong)	2, 4, 6, 8

To verify the consistency of the judgments contained in the pairwise comparison matrix, the Consistency Ratio (CR) should be calculated.

$$CR = \frac{CI}{RI}, \quad (6)$$

where: *CI* – Consistency Index, *RI* – Random Index.

The consistency index is calculated as follows:

$$CI = \frac{\lambda_{max}^{(k)} - n}{(n-1)} \tag{7}$$

where: λ_{max} - eigenvector solution, calculated as:

$$\lambda_{max}^{(k)} = \frac{\sum_{k=0}^{n} \mathrm{sw}_i^{(k)}}{s_i^{(k)}} / n \tag{8}$$

where: $sw^{(k)} = A^{(k)} s^{(k)}$ - column vector of partial sums.

According to the originator of the AHP method, the value of this coefficient should not exceed $CR \leq 0.1$. Failure to meet this condition indicates inconsistency in the decision-maker's pairwise comparisons.

Ultimately, the dependence on the consistency index can be written in the form:

$$CI = \frac{\lambda_{max}^{(k)}}{n-1\left(\left((\sum_{i=1}^{n}(sw^{(k)}/s^{(k)}))-n\right)/n\right)(n-1))} \ . \tag{9}$$

The Random Index is selected from tabulated values corresponding to the size of the comparison matrix (Table 3).

Table 3

Value of the Random Index (RI) [7,9]

Matrix Size	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0,00	0,58	0,90	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,53	1,56	1,57	1,59

It should be noted that the AHP method has gained sufficient popularity that online priority calculation tools are now widely available via web-based platforms [1,2,18].

4. Results and discussion

The AHP analysis was conducted under the assumption that the same set of criteria would be considered for both user profiles. Their selection was based on the characteristics of water obstacles defined in Section 2. For the purpose of ranking, the following criteria were selected from Table 1:

- Criterion 1 - Lane width,
- Criterion 2 - Bridge capacity (2 lines traffic),
- Criterion 3 - Bridge throughput for vehicles of the MLC 70T class,
- Criterion 4 - Bridge throughput for vehicles of the MLC 30T class,
- Criterion 5 - Minimum launching depth or the pontoon module.,
- Criterion 6 - Minimum operating depths of river,
- Criterion 7 - Permissible speed of the current,
- Criterium 8- Number of vehicles required for transporting bridge modules (100 m bridge),
- Criterion 9 - Number of soldiers for building 100 m bridge,
- Criterion 10 - Construction time (100 m bridge).

The outcome of the I Stage of the hierarchical process is presented in Tables 4–13.

Table 4

Comparison matrix for lane width

	PP-64	PFM	IRB	PP-2005
PP-64	1	2,00	0,50	0,50
PFM	0,50	1	0,33	0,33
IRB	2,00	3,00	1	1,00
PP-2005	2,00	3,00	1,00	1

Table 5

Comparison matrix for bridge capacity (2 lines traffic)

	PP-64	PFM	IRB	PP-2005
PP-64	1	7,00	5,00	0,50
PFM	0,14	1	0,33	0,11
IRB	0,20	3,00	1	0,20
PP-2005	2,00	9,00	5,00	1

Table 6

Comparison matrix for bridge throughput - MLC 70T

	PP-64	PFM	IRB	PP-2005
PP-64	1	5,00	1,00	0,20
PFM	0,20	1	0,33	0,12
IRB	1,00	3,00	1	0,20
PP-2005	5,00	8,00	5,00	1

Table 7

Comparison matrix for bridge throughput - MLC 30T

	PP-64	PFM	IRB	PP-2005
PP-64	1	3,00	6,00	0,33
PFM	0,33	1	2,00	0,14
IRB	0,17	0,50	1	0,11
PP-2005	3,00	7,00	9,00	1

Table 8

Comparison matrix for minimum launching depth

	PP-64	PFM	IRB	PP-2005
PP-64	1	3,00	2,00	1,00
PFM	0,33	1	0,50	0,33
IRB	0,50	2,00	1	0,33
PP-2005	1,00	3,00	3,00	1

Table 9

Comparison matrix for minimum launching depth

	PP-64	PFM	IRB	PP-2005
PP-64	1	0,33	0,25	1,00
PFM	3,00	1	1,00	3,00
IRB	4,00	1,00	1	4,00
PP-2005	1,00	0,33	0,25	1

Table 10

Comparison matrix for permissible speed of the current

	PP-64	PFM	IRB	PP-2005
PP-64	1	5,00	5,00	0,33
PFM	0,20	1	1,00	0,14
IRB	0,20	1,00	1	0,14
PP-2005	3,00	7,00	7,00	1

Table 11

Comparison matrix for number of vehicles

	PP-64	PFM	IRB	PP-2005
PP-64	1	0,11	0,20	0,33
PFM	9,00	1	3,00	5,00
IRB	5,00	0,33	1	3,00
PP-2005	3,00	0,20	0,33	1

Table 12

Comparison matrix for number of soldiers

	PP-64	PFM	IRB	PP-2005
PP-64	1	0,11	0,17	0,33
PFM	9,00	1	4,00	6,00
IRB	6,00	0,25	1	3,00
PP-2005	3,00	0,17	0,33	1

Table 13

Comparison matrix for construction time

	PP-64	PFM	IRB	PP-2005
PP-64	1	5,00	5,00	0,33
PFM	0,20	1	1,00	0,14
IRB	0,20	1,00	1	0,14
PP-2005	3,00	7,00	7,00	1

These tables display the pairwise comparison matrices of pontoon bridges within each of the analyzed criteria. On this basis, normalized matrices were determined, followed by the calculation of ranking values for each bridge. The obtained results are presented in a Table 14 and summarized collectively in Fig. 5.

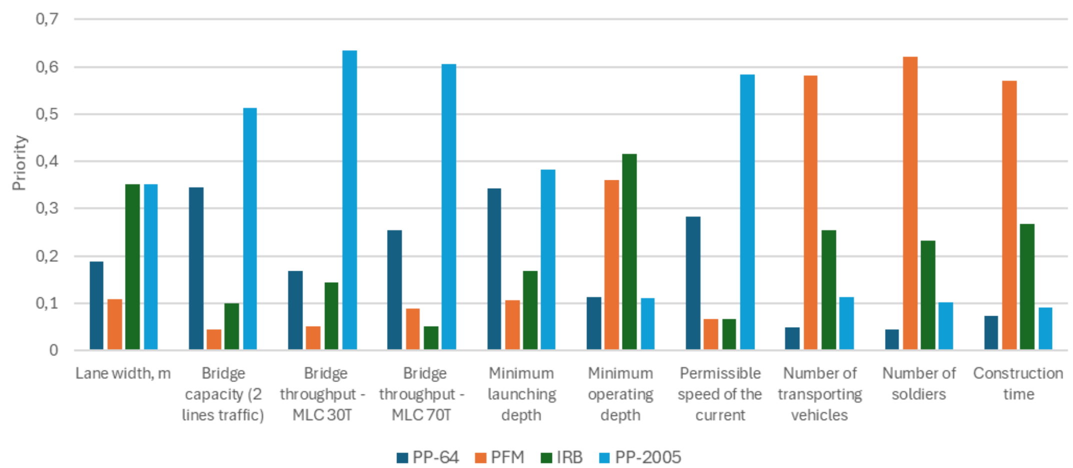

Fig.5. Priority values of the individual rankings of the analyzed ribbon pontoon bridges for the evaluated criteria

Table 14

Local priorities of the individual rankings of the analyzed ribbon pontoon bridges for the evaluated criteria

Bridge model	Criterion									
	Lane width	Bridge capacity (2 lines traffic)	Bridge throughput - MLC 30T	Bridge throughput - MLC 70T	Minimum launching depth	Minimum operating depth	Permissible speed of the current	Number of transporting vehicles	Number of soldiers	Construction time
PP-64	0,189	0,344	0,169	0,254	0,342	0,112	0,283	0,050	0,045	0,073
PFM	0,109	0,045	0,052	0,089	0,107	0,361	0,067	0,581	0,621	0,570
IRB	0,351	0,099	0,145	0,051	0,168	0,416	0,067	0,255	0,233	0,267
PP-2005	0,351	0,512	0,634	0,606	0,383	0,111	0,583	0,114	0,101	0,090

The analysis of the consistency of the assessments made showed that the CR value does not exceed the permissible level of 10% (Fig.6).

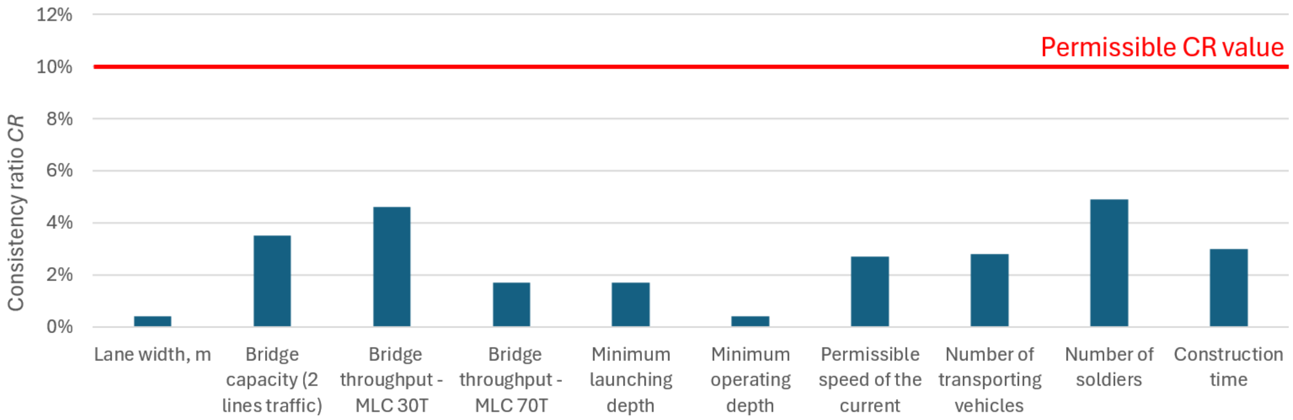

Fig.6. Consistency ratio CR values for the individual rankings of the analyzed ribbon pontoon bridges

If the obtained values from the individual rankings were aggregated without considering the weights of the criteria, the PP-2005 bridge would achieve the highest score. The PFM system would rank second, followed by the IRB in third place, while the PP-64 bridge would be placed last.

In the subsequent stage, a process of determining the weights for the adopted criteria was carried out. Table 15 presents the pairwise comparison matrix for a regulated river, while Table 16 presents the corresponding matrix for an unregulated river. For ten criteria, it was necessary to perform 45 pairwise comparisons. Achieving a value CR below 10% requires the expert assessing the mutual relationships between the comparative importance of the parameters, evaluated in pairs, to maintain a high level of rigor in assigning numerical values to the intensity of importance indicators. For both considered river characteristics, the consistency of the criteria assessment was within the acceptable threshold. The results were similar and did not exceed 9% (Fig.7).

The obtained values of the significance levels for individual criteria are presented in Table 17, as well as in Fig. 7.

An analysis of the obtained results indicates that, for both considered river characteristics, the most important operational factor is the flow velocity. The weights assigned to this criterion are similar, amounting to 27.1% and 25.4% for regulated and unregulated rivers, respectively. In both cases, the second most significant criterion is the bridge construction rate. However, in this instance the difference in weights exceeds 20%, reaching values of 18.7% and 14.8%, respectively.

The next two criteria differ in terms of their importance hierarchy. For a regulated river, these are the number of vehicles and the number of soldiers involved. In contrast, for an unregulated river, the corresponding criteria are the operational depth of the river and the discharge depth. Notably, these two criteria were found to be the least significant in the case of a regulated river.

Table 15

Pairwise comparison matrix of evaluation criteria for ribbon pontoon bridges for regulated rivers

		Parameter number									
		1	2	3	4	5	6	7	8	9	10
Parameter number	1	1	3,00	0,20	4,00	4,00	0,11	0,20	0,11	0,11	0,11
	2	0,33	1	0,20	3,00	3,00	0,14	0,20	0,11	0,11	0,11
	3	5,00	5,00	1	9,00	9,00	0,33	5,00	0,50	0,50	1,00
	4	0,25	0,33	0,11	1	1,00	0,11	0,20	0,14	0,14	0,14
	5	0,25	0,33	0,11	1,00	1	0,11	0,20	0,14	0,14	0,14
	6	9,00	7,00	3,00	9,00	9,00	1	5,00	3,00	3,00	3,00
	7	5,00	5,00	0,20	5,00	5,00	0,20	1	0,33	0,33	0,33
	8	9,00	9,00	2,00	7,00	7,00	0,33	3,00	1	1,00	0,33
	9	9,00	9,00	2,00	7,00	7,00	0,33	3,00	1,00	1	0,33
	10	9,00	9,00	1,00	7,00	7,00	0,33	3,00	3,00	3,00	1

Table 16

Pairwise comparison matrix of evaluation criteria for ribbon pontoon bridges for unregulated rivers

		Parameter number									
		1	2	3	4	5	6	7	8	9	10
Parameter number	1	1	1,00	0,20	0,25	0,25	0,11	0,20	0,14	0,14	0,14
	2	1,00	1	0,20	0,25	0,25	0,11	0,14	0,14	0,14	0,14
	3	5,00	5,00	1	0,50	0,50	0,33	5,00	2,00	2,00	1,00
	4	4,00	4,00	2,00	1	1,00	0,33	3,00	3,00	3,00	0,33
	5	4,00	4,00	2,00	1,00	1	0,33	2,00	2,00	2,00	2,00
	6	9,00	9,00	3,00	3,00	3,00	1	5,00	3,00	3,00	3,00
	7	5,00	7,00	0,20	0,33	0,50	0,20	1	0,33	0,33	0,33
	8	7,00	7,00	0,50	0,33	0,50	0,33	3,00	1	1,00	0,33
	9	7,00	7,00	0,50	0,33	0,50	0,33	3,00	1,00	1	0,33
	10	7,00	7,00	1,00	3,00	0,50	0,33	3,00	3,00	3,00	1

The fifth-ranked criterion is identical for both river characteristics, namely the throughput capacity for vehicles of MLC 70T class. Its weight amounts to 12.3% for a regulated river and 10.9% for an unregulated river. The remaining criteria are characterized by weights significantly below 10%.

By combining the results of the individual rankings of the bridges with the ranking of the criteria, in accordance with relation (5), a multicriteria ranking was obtained for the analyzed ribbon-type pontoon bridges. The results are presented in Table 18 and illustrated in Fig. 9.

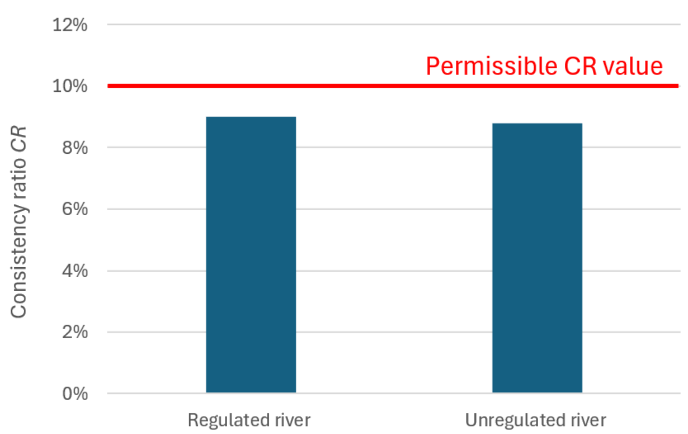

Fig.7. Consistency ratio CR values for the criteria rankings of the analyzed ribbon pontoon bridges

Table 17

Criterion ranking for analyzed river characteristics - significance level and rank

Bridge parameter		Regulated river		Unregulated river	
		Significance level	Rank	Rank	Significance level
1	Lane width	3,0%	**7**	**9**	1,8%
2	Bridge capacity (2 lines)	2,2%	**8**	**10**	1,8%
3	Bridge throughput for vehicles of the MLC 70T class	12,3%	**5**	**5**	10,9%
4	Bridge throughput for vehicles of the MLC 30T class	6,3%	**6**	**8**	4,9%
5	Minimum launching depth of the pontoon module	1,5%	**9**	**4**	12,3%
6	Minim. operating depths	1,5%	**9**	**3**	12,7%
7	Permissible speed of the current	27,1%	**1**	**1**	25,4%
8	Number of transporting vehicles	13,7%	**3**	**6**	7,7%
9	Number of soldiers	13,7%	**3**	**6**	7,7%
10	Construction time (100 m)	18,7%	**2**	**2**	14,8%

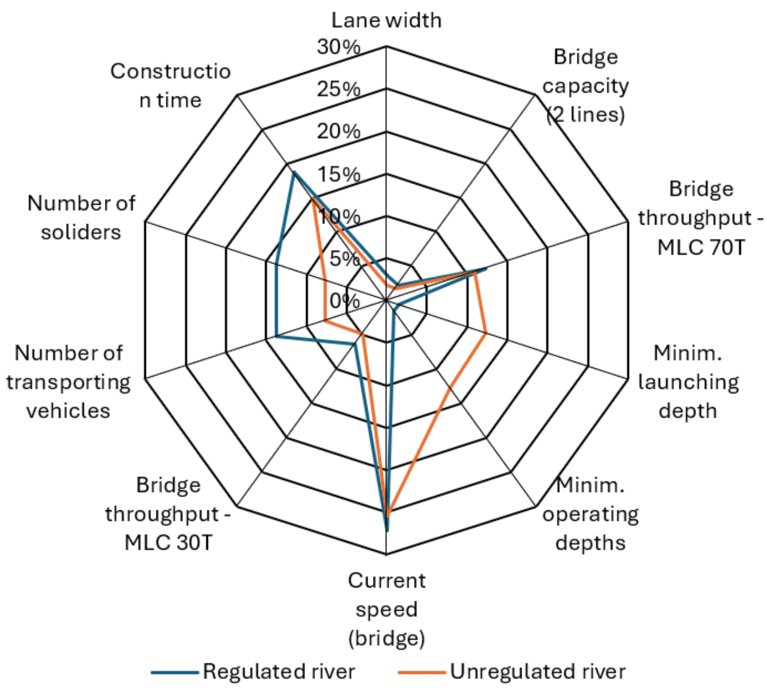

Fig.8. Criterion rank for each characteristic of river

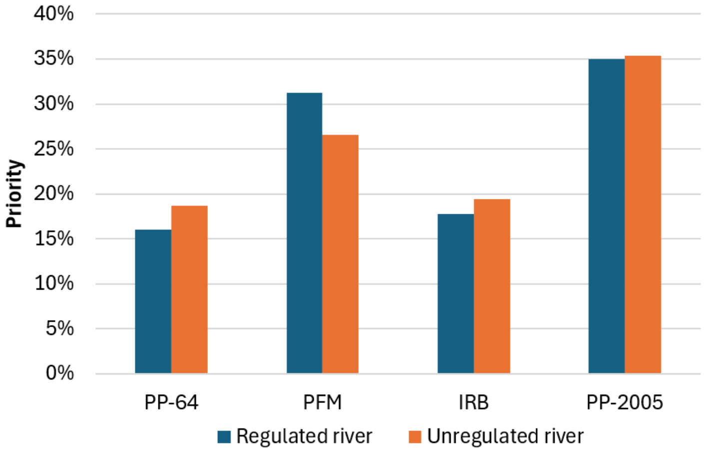

Fig.9. Multi-criteria ranking of ribbon pontoon bridges for two river characteristics - AHP analysis results

Table 18

Multi-criteria ranking of ribbon pontoon bridges
- significance level and rank

Name of bridge	Regulated river		Unregulated river	
	Significance level	Rank	Rank	Significance level
PP-2005	34,97%	**1**	**1**	35,36%
PFM	31,29%	**2**	**2**	26,59%
IRB	17,73%	**3**	**3**	19,39%
PP-64	15,99%	**4**	**4**	18,65%

The conducted analysis demonstrated that, for both considered river characteristics and the selected evaluation criteria, the analyzed ribbon-type pontoon bridges achieved the same ranking positions. The Russian PP-2005 proved to be the best option, followed by the French PFM in second place and the American IRB in third. The Polish PP-64 ranked last.

It can also be stated that the differences in evaluation between the two leading bridges amount to approximately 33% for a unregulated river, and only about 12% for an unregulated river. In contrast, with respect to the American IRB, the French PFM achieved nearly twice as high a score for both river characteristics. Relatively small differences are observed between the bridges ranked third and fourth. This is particularly evident for the regulated river, where the difference is less than 4%.

5. Conclusions

The conducted multi-criteria evaluation of selected structural solutions for ribbon pontoon bridges indicates that the application of the Analytic Hierarchy Process (AHP) yields satisfactory results. For the adopted set of criteria, the PP-2005 bridge emerged as the optimal solution. This Russian design has the longest developmental history and constitutes the prototype for all modern pontoon bridges, originating from the PMP model introduced in 1960. The ranking outcome thus reflects extensive long-term experience in both design and operational use.

The French PFM bridge, ranked second, differs significantly in its structural design from the Russian PP-2005. It demonstrates clear advantages, particularly in terms of the number of required transport vehicles and personnel, as well as reduced construction time. However, it does not permit two-lane traffic for light vehicles (below MLC 30), which substantially limits its throughput capacity. It is also less resistant to river current forces. These key advantages and disadvantages account for its position in the ranking—below the PP-2005 bridge, yet above the IRB system.

The conducted assessment does not encompass all tactical and technical parameters. It should be noted, however, that the number of criteria that can be effectively applied within the AHP method is inherently limited. This constraint is reflected in the size of the matrices used to determine the Consistency Ratio (CR). In the available literature, these matrices typically do not exceed values corresponding to 15–20 criteria. As the number of criteria increases, maintaining the Consistency Index (CI) below the acceptable threshold of 10% becomes increasingly difficult.

In the present analysis, for four-element individual rankings, it was possible to achieve CI values below 5%. However, for a ten-element set of criteria, the resulting value approached approximately 9%. Based on these observations, it can be concluded that, given the limited number of criteria that can be reliably considered, their proper selection plays a crucial role. This, in turn, requires the careful selection of experts conducting the evaluation, who are capable not only of identifying the key factors but also of assigning them appropriate intensities of importance in pairwise comparisons.

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