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APPLICATION OF THE SWOT-TOWS ANALYSIS AS A SUPPORTING TOOL WHEN SELECTING A STRATEGY FOR THE IMPLEMENTATION OF LOCAL CONCRETE ROADS

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Purpose: The aim of the article is to present the practical application of the SWOT-TOWS analysis when choosing a strategy for the implementation of local government roads in concrete technology.
Design/methodology/approach: The research includes the identification of the characteristics of concrete pavement and the indication of the most advantageous action strategy using the SWOT analysis extended by examining additional TOWS connections. Elements of the statistical and observational methods were used, based on literature reports.
Findings: The analysis showed a correlation between internal and external factors, which resulted in the selection of the most optimal solution in the examined case, which turned out to be an aggressive strategy.
Research limitations/implications: The presented analysis is not comprehensive, but it is a helpful tool for strategic analysis, the results of which are important information for further research on the discussed issue.
Practical implications: The presented analysis can be successfully used by investors and contractors as an auxiliary tool when choosing a road investment implementation strategy, thanks to the possibility of adjusting the criteria of weights conditioned by the location of a given project and the agreed preferences.
Originality/value: Simultaneous use of the SWOT-TOWS analysis with other analytical tools will allow in practice for quick and easy decision making when choosing the most advantageous strategy for the implementation of road investments.

Keywords: SWOT-TOWS analysis, local government roads, concrete roads, road investments.

Category of the paper: Research paper.

1. Introduction

Communal and district roads account for approximately 88% of all roads in Poland. The main problem for the administrators of these roads is their poor technical condition, which is largely due to insufficient financial resources to cover the costs of repairs necessary to be carried out. The need for remedial action concerns mainly bitumen roads, which are the dominant part of the road network in Poland. According to the data of the Polish Cement Association, as much as 80% of municipal roads and 90% of district roads require immediate renovation. Based on the results of CATI surveys conducted in 2022, the main causes of damage to local government roads were determined. These include, among others: freight transport (in 46% of the surveyed local governments), maladjustment of the pavement to local conditions (15%) and improper construction of the pavement (9%) (Tobota, 2022).

The solution to the existing problem may be the construction of roads with a concrete pavement. According to the report of the European Concrete Paving Association prepared at the end of 2021, concrete pavements have been implemented on over 45 km of provincial roads, 600 km of district roads and 1,200 km of municipal roads (Deja, 2022). According to the data of the General Directorate for National Roads and Motorways, there are currently about 1000 km of motorways and expressways, which constitutes about 21% of the road network.

Concrete technology fits very well into the area of activities related to environmental protection. This material is environmentally friendly due to its recycling features. In addition, it creates the possibility of secondary management of various types of waste, including waste from polymeric materials and waste from the copper industry (Pietrzak, 2018; Helbrych, 2019). Often these activities also improve the quality of concrete. Tests carried out on concrete samples modified with polypropylene fibers have shown that the resulting composite has better frost resistance, which is an important aspect in the case of concrete pavement exposed to cyclical frost (Pietrzak, Ulewicz, 2018). In recent years, the implementation of local roads in rolled concrete technology has become increasingly popular (Gruszczyński, 2016; Przybylski, 2021). This solution enables the use of equipment intended for asphalt works, which significantly facilitates the construction of new roads (Piestrzyński, 2022).

Unfortunately, despite the constantly increasing length of the local government concrete road network (approx. 150 km per year), investors and contractors still have low awareness of the advantages and benefits of using this technology. Faced with the choice of implementation technology, they most often decide on a solution that is less complicated in their opinion, which is the implementation of asphalt pavements. An additional argument is the dominance of contractors specializing in the construction of roads using this technology on the market. Therefore, it is obvious that it is necessary to make decision-makers aware of the advantages and disadvantages of all possible solutions, using easy-to-use supporting tools. It is important that the chosen action strategy is as cost-effective and effective, both at the implementation and operational stages. The use of the SWOT-TOWS analysis will make it possible to identify the strengths and weaknesses of a given solution, identify the resulting opportunities and threats, and the impact of the environment on internal factors. Thanks to this, it is possible to easily and quickly estimate which strategy should be adopted so that the process of implementing the planned road investment is as beneficial as possible in given conditions (Nieżurawski, Nieżurawska-Zając, 2021). SWOT analysis is a tool often used in the construction industry. In the study (Matuszko, Parzych, Hozer, 2018) it was used to determine the possibility of introducing low-energy construction to the Polish market. The advantage of the strengths of such a solution over the weaknesses allowed us to conclude that it is necessary to take actions aimed at the development of this type of construction. Another example is the use of the SWOT analysis to select an action strategy in construction companies dealing, for example, in the production of cement (Szczesny, Klimecka-Tatar, 2017), comprehensive construction of single-family houses (Czajkowska, 2016), or the production of window and door joinery elements (Ingaldi, Jagusiak-Kocik, 2014). It is worth noting that for the purposes of obtaining more detailed results, the basic concept of the SWOT analysis can be modified, for example by expanding TOWS links or creating a TOWS-SWOT hybrid, which is used in the assessment of activities related to construction projects implemented as part of innovative construction (Miszewska, Niedostatkiewicz, 2020). The SWOT-TOWS analysis can be a useful tool supporting the management of construction companies, but it should be used in conjunction with other analytical tools. Currently, many companies are implementing the Lean Management concept in order to improve the implementation of projects in accordance with the assumed budget, schedule and quality level, which can significantly contribute to increasing the effectiveness of activities undertaken in enterprises (Ulewicz, R., Kleszcz, Ulewicz, M., 2021; Ulewicz, R., Ulewicz, M., 2019).

The aim of the research was to present the use of the SWOT-TOWS analysis as a tool supporting the selection of a strategy at the planning stage of a road investment in concrete technology.

2. Features of concrete pavements

The strength of roads with a concrete pavement is primarily their high durability and resistance to rutting, which translates into their longer service life. The service life of concrete roads is estimated at up to 50 years (Korentz et al., 2021). In addition, these pavements do not require as frequent renovations and repairs as their asphalt counterparts. However, if there is a need to carry out renovation activities, it is a more complex process, due to the need to replace the entire slab using heavy specialized equipment. This results in higher financial costs and a long waiting period for the repair to be completed. Cutting expansion joints in the concrete pavement results in division into slabs, which can lead to the phenomenon of "keying". This effect negatively affects both driving comfort and sound quality. Compared to asphalt pavements, the implementation of concrete roads is associated with a long waiting time for commissioning, due to the fact that the concrete reaches its full strength only after 28 days. Therefore, concrete pavements are implemented in undeveloped areas, they work well as access roads, bicycle paths or in industrial areas. The initial costs generated by the construction of concrete roads often exceed the costs of implementing roads in asphalt technology, but in the perspective of the entire period of operation, concrete roads are a more profitable solution. The easy availability of raw materials for the production of concrete mix and the developed infrastructure in terms of the availability of concrete mixing plants and the necessary machines in almost every location are also important. However, it should be remembered that concrete works are highly dependent on the prevailing weather conditions. Too low temperature prevents them from being carried out, and additional care treatments are required during hot weather.

The construction of roads with a concrete pavement is a great opportunity to improve road safety also due to their good reflectivity. Due to the light color of the material used, traffic participants and road technical devices are better visible to the driver, which creates good conditions to reduce the number of accidents and collisions. In addition, the lack of negative impact on the environment allows the use of this solution in "green" and protected areas (Deja, 2021).

3. Methodology of research

The research was carried out using the SWOT-TOWS analysis. As part of the SWOT analysis, input data on concrete pavements obtained from current literature reports were divided into 4 categories: strengths and weaknesses as well as opportunities and threats, from which 5 priority features were selected, each of which was assigned the appropriate weight (Table 1). The sum of the weights in each category was 1. Next, tables were developed containing answers to the questions of how internal factors (strengths and weaknesses) affect external factors (opportunities and threats). For this purpose, the identification of dependencies in the 0/1 system was used, where "0" means no links, and "1" the presence of dependencies. The next step in this part of the analysis was to add up the number of interactions in each row and column and assign a rank, defining the strength of a given feature, on a scale of 1 to 5. Based on the weighted values obtained, the rank "1" was assigned the highest value obtained, while the rank "5" - the lowest.

The SWOT analysis was supplemented with TOWS links, i.e. the study of dependencies “from outside to inside” in a similar way. The last stage of the work was to prepare a tabular summary containing the number of interactions and their weighted number, which are the sum of the connections of the SWOT and TOWS matrix systems, and to indicate, based on the highest result, one of the four action strategies to be adopted (Kowalik, 2020; Sadłowska-Wrzesińska, Marczewska-Kuźma, Jakubowicz, 2020; Kucharczyk, Kardas, 2018):

- aggressive (maxi-maxi) - strengths and opportunities prevail; this strategy consists in strong development and expansion of activities with the maximum use of strengths,
- conservative (maxi-mini) - strengths and threats predominate; the strategy consists in using the strengths in order to minimize the existing threats to the environment,
- competitive (mini-maxi) – weaknesses and opportunities predominate; strategy is to take advantage of emerging opportunities while eliminating weaknesses,
- defensive (mini-mini) – weaknesses and threats predominate; the strategy consists in counteracting weaknesses and threats so as to ensure the possibility of survival in unfavorable environmental conditions.

Table 1.
List of SWOT factors with the weights assigned to them

S	Strengths	Weight	W	Weaknesses	Weight
S1	High durability	0.3	W1	Cannot be used on bridges	0.15
S2	Availability of raw materials for making concrete	0.2	W2	The need to cut expansion joints and texture the pavement	0.15
S3	Rutting resistance	0.2	W3	Difficult demolition of the pavement	0.25
S4	Good reflectivity	0.05	W4	Long technological breaks after concreting	0.25
S5	Developed infrastructure (concreting plants, machines)	0.25	W5	Concrete corrosion	0.2
O	**Opportunities**	**Weight**	**T**	**Threats**	**Weight**
O1	Increasing road safety	0.25	T1	High investment costs	0.2
O2	Low running costs	0.2	T2	Limited scope of use	0.15
O3	Development of infrastructure mainly in undeveloped areas	0.25	T3	Long and costly repairs and renovations	0.25
O4	No negative impact on the environment	0.15	T4	Possibility of "keying" or cracking of the pavement	0.1
O5	Management of recycled materials	0.15	T5	Time-consuming execution	0.3

S – Strengths; W – Weaknesses; O – Opportunities; T – Threats.

Source: own study.

4. Results and discussion

Tables 2-5 present the results of the "inside-out" factor analysis, which are the answers to the following questions: does the strength enhance the given opportunity? (Table 2); does the strength mitigate the threat? (Table 3); does the weakness prevent taking advantage of the opportunity? (Table 4); whether the weakness amplifies the threat (Table 5).

Table 2.
Dependence strengths/opportunities

S/O	O1	O2	O3	O4	O5	Weight	N	S	R
S1	1	1	1	0	0	0.3	3	0.9	1
S2	0	1	1	1	1	0.2	4	0.8	2
S3	1	1	1	0	1	0.2	4	0.8	2
S4	1	1	1	0	0	0.05	3	0.15	5
S5	0	0	1	0	1	0.25	2	0.5	4
Weight	0.25	0.2	0.25	0.15	0.15				
N	3	4	5	1	3		32		
S	0.75	0.8	1.25	0.15	0.45			6.55	
R	3	2	1	5	4				

N – number of interactions; S – interaction weighted value; R – rank.

Source: own study.

Table 3.
Dependence strengths/threats

S/T	T1	T2	T3	T4	T5	Weight	N	S	R
S1	0	0	1	1	0	0.3	2	0.6	2
S2	1	1	0	0	1	0.2	3	0.6	2
S3	0	0	1	1	0	0.2	2	0.4	4
S4	1	0	0	0	0	0.05	1	0.05	5
S5	1	1	1	0	1	0.25	4	1	1
Weight	0.2	0.15	0.25	0.1	0.3				
N	3	2	3	2	2		24		
S	0.6	0.3	0.75	0.2	0.6			5.1	
R	2	4	1	5	2				

Source: own study.

Table 4.
Dependence weaknesses/opportunities

W/O	O1	O2	O3	O4	O5	Weight	N	S	R
W1	0	0	0	0	1	0.15	1	0.15	4
W2	0	0	0	0	0	0.15	0	0	5
W3	0	1	0	0	1	0.25	2	0.5	1
W4	0	0	1	0	0	0.25	1	0.25	3
W5	1	1	0	0	0	0.2	2	0.4	2
Weight	0.25	0.2	0.25	0.15	0.15				
N	1	2	1	0	2		12		
S	0.25	0.4	0.25	0	0.3			2.5	
R	3	1	3	5	2				

Source: own study.

Table 5.
Dependence weaknesses/threats

W/T	T1	T2	T3	T4	T5	Weight	N	S	R
W1	0	1	0	0	0	0.15	1	0.15	5
W2	1	0	0	1	1	0.15	3	0.45	2
W3	0	0	1	0	0	0.25	1	0.25	4
W4	1	1	1	0	1	0.25	4	1	1
W5	1	0	0	1	0	0.2	2	0.4	3
Weight	0.2	0.15	0.25	0.1	0.3				
N	3	2	2	2	2		22		
S	0.6	0.3	0.5	0.2	0.6			4.45	
R	1	4	3	5	1				

Source: own study.

The obtained data show that the greatest number of connections (32) are between the categories "strengths/opportunities" and its weighted value is 6.55. Interestingly, similar results were obtained for the relationships "strengths/threats" (24) and "weaknesses/threats" (22). The fewest interactions were identified between the "weaknesses/opportunities" categories (12) with a weighted number of 2.50.

Table 6.
Dependence opportunities/strengths

O/S	S1	S2	S3	S4	S5	Weight	N	S	R
O1	0	0	0	1	0	0.25	1	0.25	3
O2	0	0	1	0	0	0.2	1	0.2	4
O3	1	1	0	0	1	0.25	3	0.75	1
O4	0	1	0	0	1	0.15	2	0.3	2
O5	0	0	0	0	0	0.15	0	0	5
Weight	0.3	0.2	0.2	0.05	0.25				
N	1	2	1	1	2		14		
S	0.3	0.4	0.2	0.05	0.5			2.95	
R	3	2	4	5	1				

Source: own study.

Table 7.
Dependence threats/strengths

T/S	S1	S2	S3	S4	S5	Weight	N	S	R
T1	0	0	0	0	0	0.2	0	0	3
T2	0	0	0	0	0	0.15	0	0	3
T3	1	0	0	0	0	0.25	1	0.25	1
T4	1	0	0	0	0	0.1	1	0.1	2
T5	0	0	0	0	0	0.3	0	0	3
Weight	0.3	0.2	0.2	0.05	0.25				
N	2	0	0	0	0		4		
S	0.6	0	0	0	0			0.95	
R	1	2	2	2	2				

Source: own study.

Table 8.
Dependence opportunities/weaknesses

O/W	W1	W2	W3	W4	W5	Weight	N	S	R
O1	0	0	0	0	0	0.25	0	0	2
O2	0	0	0	0	0	0.2	0	0	2
O3	0	0	0	0	0	0.25	0	0	2
O4	0	0	0	0	1	0.15	1	0.15	1
O5	0	0	0	0	0	0.15	0	0	2
Weight	0.15	0.15	0.25	0.25	0.2				
N	0	0	0	0	1		2		
S	0	0	0	0	0.2			0.35	
R	2	2	2	2	1				

Source: own study.

Table 9.
Dependence threats/weaknesses

T/W	W1	W2	W3	W4	W5	Weight	N	S	R
T1	0	0	0	0	0	0.2	0	0	4
T2	0	0	0	0	0	0.15	0	0	4
T3	0	1	0	1	1	0.25	3	0.75	1
T4	0	1	1	0	0	0.1	2	0.2	3
T5	0	0	0	1	0	0.3	1	0.3	2
Weight	0.15	0.15	0.25	0.25	0.2				
N	0	2	1	2	1		12		
S	0	0.3	0.25	0.5	0.2			2.5	
R	5	2	3	1	4				

Source: own study.

The results of the “outside-inside” factor relationship analysis are presented in tables 6-9. They contain answers to the following questions: will the identified opportunity increase the strength? (Table 6); Will the identified threat weaken the strength? (Table 7); whether the identified opportunity will mitigate the given weakness? (Table 8); Will the identified threat magnify the given weakness? (Table 9).

Based on the results of the TOWS analysis, it was found that the largest number of associations (14) and the highest weighted number of interactions (2.95) occurred between the “opportunities/strengths” categories. It is worth noting that the number of interactions was only 2 less in the case of the “threats/weaknesses” relationship. The smallest correlation (2) occurred between the “opportunities/weaknesses” categories, where the weighted number of interactions was only 0.35.

Table 10 presents a summary of the results of the SWOT-TOWS analysis with a reference to the action strategy. According to the obtained data, the highest number of interactions equal to 46 and the highest weighted value of 9.50 were recorded between the categories “strengths/opportunities”. In such a situation, the most optimal solution is to adopt an aggressive strategy based on the use of the advantages of concrete technology, which include, above all, high durability and easy availability of raw materials and machines for making the concrete mix. The development of these features will allow for greater opportunities in the context of road safety, environmental protection and savings resulting from the operation of these roads.

Table 10.
A summary of the obtained results of the SWOT-TOWS analysis

	Opportunities	**Threats**
Strengths	**Aggressive strategy**	**Conservative strategy**
	Number of interactions 46	Number of interactions 28
	Weighted number of interactions 9.50	Weighted number of interactions 6.05
Weaknesses	**Competitive strategy**	**Defensive strategy**
	Number of interactions 14	Number of interactions 34
	Weighted number of interactions 2.85	Weighted number of interactions 6.95

Source: own study.

5. Conclusions

On the basis of the literature analysis, the strengths and weaknesses of roads with a concrete pavement as well as the opportunities and threats resulting from their implementation were identified. The conducted SWOT-TOWS analysis determined the most optimal solution in the examined case, which would be the adoption of an aggressive strategy. Contractors, deciding to implement roads in concrete technology, should therefore focus on strengthening its advantages in order to achieve the desired effects. However, it should be remembered that the SWOT-TOWS method in this case provides a structured approach, not a comprehensive solution to the problem. It only defines a potential strategy of action that can be adopted, but does not contain a detailed plan for its implementation.

In conclusion, the SWOT-TOWS analysis can be a useful tool supporting the selection of a strategy for the implementation of local concrete roads. However, it should be used in conjunction with other analytics tools. The SWOT-TOWS analysis should not be treated as the sole basis for decision-making.

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