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Methods Prioritization of Concrete Structures Retrofitting in Mazandaran Province by TOPSIS[1] model

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ABSTRACT

Reinforced concrete buildings include a high amount of existing buildings of the country. A considerable percentage of these buildings require more retrofitting, shake optimization and maintenance due to couple of reasons such as changes in the structure regulations, building bugs, application change and etc. So far, different methods have been introduced to stiffen the construction. In order to select the best method, one requires information, reliable scientific and experimental comparisons and modern decision modeling. In this research, firstly the usual reinforcement methods in Mazandaran are recognized and basic factors for comparison are specified based on which some objective questionnaires are made by experts in reinforcement issue. Ideal choice or TOPSIS model which is a multi-criteria decision analysis method were used to review, analyze and conclude these questionnaires. According to the conclusions shear wall and FRP methods earned higher priorities to be used for reinforcement.

Key words : Retrofitting methods, reinforced concrete and TOPSIS.

INTRODUCTION

Concrete buildings include a high amount of existing buildings of the country. A considerable percentage of these buildings require more retrofitting, Seismic rehabilitation and maintenance due to couple of reasons such as changes in the structure regulations, building Implementation bugs, application change and etc. In this research usual retrofitting methods for concrete structures in Mazandaran were compared and TOPSIS model which is a multi-criteria decision making model were used. (Elyasian , 2008).

In the process of organizational decision making, managers usually to follow the sanity of approaches, define the problem and gather all its facts based on time horizons, coverage and sensitivity. They regulate and prioritize the solutions, and then they will select one of the options that go with condition, capabilities, requirements and time and finally put it in use. (KHazaei.Javad and SHayesteh.Meisam, 2011)

The research includes reviewing of concrete structures retrofitting in three main cities of Mazandaran based on the existing condition, and the interviewees were asked to answer the comparison questions according to the criteria of 5 years ago.

Date collection and analysis must be in a way that well covers all the population and the amount of input data must be enough to generate a good reliability so that be documented. In this research all the society individuals had the same chance to choose a sample and questionnaires distribution among the structure experts with masters and PhD degrees with at least 10 years of experience. The individuals who were asked were consisted of structure experts of Mazandaran especially in retrofitting and also university professors. At last

affective factors in order of importance sorted out and most important factor was chosen. In this research, the combinational method was used to extract data. The method works in such way that a weight combination of each category works as a priority. Data analysis and presentation are done by TOPSIS software. (Tareghian, 2009.)

Data Collection:

In this research, the data are collected through questionnaires, questionnaires on which analysis makes the main body of the research. The design is in a way that interviewees compare the retrofitting methods two by two. Some criteria were considered for retrofitting methods comparison that for each criterion a distinctive name was chosen. A questionnaire was chosen for criteria importance comparison so that the importance and amount of criteria advantages could be ranked.

Criteria which used for retrofitting methods comparison in Mazandaran include: 1. Time of implementation 2. Cost of materials 3.Uninterrupted utilization of the structure while methods are implementing 4. Adaptability of the method with seismic analysis (by software's).

Methods which were not usual in Mazandaran kicked out of research and methods such as 1. Steel bracings (same axis, and out axis) 2. Shear wall 3.Mid-framed (with masonry materials). 4.Concrete pod5.Concrete cover with reinforced mortar and 6.FRP were included in the research that are usual in Mazandaran and taken into comparison and practice priority review. In the following figure, a sample of questionnaire designed for methods comparison is presented.

Data analysis

Results generated by TOPSIS method. the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is a multi-criteria decision analysis method, which was originally developed by Hwang and Yoon in 1981(Hwang.C.L., Zadeh L.A, 1970). TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. It is a method of compensatory aggregation that compares a set of alternatives by identifying weights for each criterion, normalizing scores for each criterion and calculating the geometric distance between each alternative and the ideal alternative, which is the best score in each criterion. An assumption of TOPSIS is that the criteria are monotonically increasing or decreasing.(Hwang *et al*., 1993)

Step 1: Construct normalized decision matrix.

This step transforms various attribute dimensions into non-dimensional attributes, which allows comparisons across criteria. Normalize scores or data as follows:

$$n_{ij} = \frac{r_j}{\sqrt{\sum_{i=1}^{m} r_j^{\,2}}} \qquad ...(1)$$

Step 2: Construct the weighted normalized decision matrix.

Assume we have a set of weights for each criteria w_j for j = 1,…n. Multiply each column of the normalized decision matrix by its associated weight.

An element of the new matrix is:

$$V = N_D.W_{n\times n} = \begin{vmatrix} V_{11},\ldots,V_{1j},\ldots V_{1n} \\ V_{m1},\ldots,V_{jn},\ldots V_{mn} \end{vmatrix} \qquad ...(2)$$

Step 3: Determine the ideal and negative ideal solutions.

Ideal solution:

$$A^+ = \left\{\left(\max V_{ij} \,|\, j \in J\right)\left(\min V_j \,|\, j \in J'\right) i = 1,2,\ldots m\right\}$$
$$= \left\{V_1^+, V_2^+, \ldots V_j^+, \ldots V_n^+\right\} \qquad ...(3)$$

Negative ideal solution:

$$A^- = \left\{\left(\min_i V_j \,|\, j \in J\right)\left(\min_i V_j \,|\, j \in J'\right) = 1,2,\ldots m\right\}$$
$$= \left\{V_1^-, V_2^-, \ldots V_j^-, \ldots V_n^-\right\} \qquad ...(4)$$

Step 4: Calculate the separation measures for each alternative.

The separation from the ideal alternative is:

$$d_{i+} = \left\{ \sum_{j=1}^{n} \left(V_{ij} - V_j^{+} \right)^2 \right\}^{0/5} \qquad i = 1,2,...,m \qquad ...(5)$$

Similarly, the separation from the negative ideal alternative is:

$$d_{i-} = \left\{ \sum_{j=1}^{n} \left(V_{ij} - V_j^{-} \right)^2 \right\}^{0/5} \qquad i = 1,2,...,m \qquad ...(6)$$

Step 5: Calculate the relative closeness to the ideal solution:

$$\text{ċ}_i = \frac{d_i}{\left(d_{i+} + d_{i-} \right)}, \qquad ...(7)$$

$$i = 1,2,...,m \quad 0 \le \text{ċ}_{i+} < 1$$

Step 6: Rank the alternatives

In using vector normalization, the non linear distances between single dimension scores and ratios should produce smoother trade offs.(Huang *et al.*, 2011).

Table 1:

FRP	Concrete cover	Concrete pod	Mid-framed	.Shear wall	Steel bracings	
1/5	1/3	3	5	7	1	Steel bracings
1/9	1/8	1/5	1/3	1	1/7	. Shear wall
1/9	1/7	1/3	1	3	1/5	Mid-framed
1/7	1/5	1	3	5	1/3	Concrete pod
1/3	1	5	7	8	3	Concrete cover
1	3	7	9	9	5	FRP

Table 2: Prioritizing the options based on different criteria

	Time of implementation	Cost of materials	adaptability	uninterrupted utilization
Priority 1	FRP	FRP	Shear wall	FRP
Priority 2	Concrete cover	Concrete cover	Steel bracings	Concrete cover
Priority 3	Steel bracings	Mid-framed	Concrete cover	Shear wall
Priority 4	Concrete pod	Concrete pod	Mid-framed	Concrete pod
Priority 5	Mid-framed	Steel bracings	Concrete pod	Mid-framed
Priority 6	Shear wall	Shear wall	FRP	Steel bracings

Table 3: Criterion binary comparison

uninterrupted …	adaptability	Cost of …	Time of …	
1/5	1/5	3	1	Time …
1/5	1/7	1	1/3	Cost …
3	1	7	5	adaptability
1	1/3	5	3	uninterrupted …

Based on the questionnaires qualitative factors are turned into quantitative factors. In the binary matrix comparison, each array shows the criterion line importance amount corresponding to column criteria. In Table 1 criterion binary comparison matrix is presented. Binary comparison matrix arrays are the result of geometric average of the interviewees and decision makers' ideas. In this chart, each array's weight is presented.

In the matrix of binary comparisons, the amount of each matrix element shows the line criteria importance degree corresponding to the column criteria. In Table 1, binary comparison matrix of options is presented according to the time, easiness of practice and plan limitations factors. The arrays of this matrix are the result of geometric average of the interviewees and decision makers' ideas with same decision making power.

Options binary comparison matrix corresponding to the time, easiness of practice and plan limitations factors:

As it is shown in the chart, FRP papers show the best performance according to the time, easiness of practice and plan limitations factors. So the other criterion is weighted with the same sample. After achieving the weight for each option considering different criteria, the priority of each option is shown in Table 2 based on different criterion.

To calculate the structure using TOPSIS method, criterion binary comparison is needed and this binary comparison matrix is presented in Table 3.

Table 4: Minimum and maximum amounts of each criterion in TOPSIS method

	Time of …	Cost of …	adaptability	uninterrupted …
min	0.00096	0.0011	0.10336	0.0064
max	0.1711	0.20525	1.79675	1.14284

In TOPSIS method, minimum and maximum amounts of each criterion is needed which is shown in Table 4.

For each option, the ideal positive and negative amounts are shown in Table 5 and 6.

Relative proximity of each option is calculated by ideal solution that is shown in Table 7.

Table 5: The ideal positive and negative amounts in TOPSIS method

Method	Weight
Steel bracings	1.226
Shear wall	0.636
Mid-framed	1.7333
Concrete pod	1.7507
Concrete cover	0.9567
FRP	1.69339

Table 6: The ideal positive and negative amounts in TOPSIS method

Method	Weight
Steel bracings	1.27889
Shear wall	1.78
Mid-framed	0.4
Concrete pod	0.36382
Concrete cover	0.9567
FRP	1.167

Table 7: Relative proximity of options created by ideal solution and options prioritizing by TOPSIS Method

Method	Weight
Steel bracings	0.51055
Shear wall	0.73675
Mid-framed	0.1875
Concrete pod	0.172
Concrete cover	0.6151
FRP	0.4

In TOPSIS method, the more relative proximity, the more ideal its corresponding options are. According to the results by TOPSIS method, shear wall is the best solution to optimization and retrofitting of the reinforced concrete structures.

CONCLUSIONS

After review and analysis of the options, conclusions are as follows:

1. According to the results of Table 2, FRP layers are the best systems to concrete reinforced structures considering time factor.
2. According to the results of Table 2, FRP layers are the best systems to concrete reinforced structures considering the cost factor.
3. According to the results of Table 2, shear walls are the best systems to concrete reinforced structures considering method compatibility criteria with shake analysis.
4. According to the results of Table 2, FRP layers are the best systems to concrete reinforced structures considering uninterrupted utilization.
5. According to results of Table 3, adaptability of the method with seismic analysis isMost important criteria in retrofitting and optimization.
6. Considering the weight of each criteria and using TOPSIS method and all aspects, shear wall is the best system for optimization and retrofitting.

REFERENCES

1. Elyasian.Iman,"methods of rehabilitation reinforced concrete construction",*Roads and buildings Monthlies*, **6**: 56, (2008).
2. KHazaei.Javad and SHayesteh.Meisam "EffectiveFactors on Decision making", *National Conference of Structures, Road&Architecture*, Azad University of CHalus, (2011)
3. Tareghian,Hamedreza, "projects Planning and Control", First Edition, Mashhad, (Publications of Azad University of Mashhad, 2009.)
4. Hwang.C.L., Zadeh L.A "Decision-making in a fuzzy environment", *Management Sciences* **17**: 141-164..(1970),
5. Hwang, C.L.; Lai, Y.J.; Liu, T.Y.."A new approach for multiple objective decisionmaking". *Computers* (1993)
6. Huang, I.B.; Keisler, J.; Linkov, I. "Multi-criteria decision analysis in environmental science: ten years of applications and trends". *Science of the Total Environment.* (2011).