# A Prediction Model for the Pavement Condition Index using the International Roughness Index: A Case Study of 5 Selected Freeways in Iran

Seyed Azim Hosseini[1]    Masoud Sabaee[2]

Seyed Amir Saadatjoo[3]    Saeed Fatemi[4]

Seyed Ali Ziaee[5]

## 1. Introduction

Reliable and accurate assessment of current condition of the pavement network is one of the most important components in a pavement management system. This assessment is achieved through continuous visual inspection of the pavement condition. For example, the amount of cracking of the pavement surface can be evaluated and the predominant failures of each part of the pavement network can be recognized. Currently, driving quality is considered as an essential element of pavement performance and user satisfaction. One of the most important parameters affecting the driving quality and users' views about the level of road services is the level of roughness of the pavement surface. The degree of pavement roughness can be assessed by determining the International Roughness Index (IRI). This index is equal to the sum of the vertical movements divided by the distance traveled by the navigation vehicle at a speed of 80 km/h. On the other hand, the PCI index is the most widely used criterion for assessing the conditions of pavement in most countries. This index is a comprehensive criterion for existing pavement conditions, which is explained based on the observed failures and their statistical analysis for pavement sampling, and shows the structural integrity of the pavement and the functional status of its surface. In this index, 19 different types of failures with different levels of intensity (low, medium, and high) are examined.

In recent years, various studies have been conducted to link PCI and IRI indices. In 2019, Elhadidy et al. using 10868 pavement failure data, obtained the following equation to determine IRI from PCI with $R^2=0.995$:

$$IRI = \left( \frac{79.933}{14.061 + \exp(0.048 * PCI)} \right) \quad (1)$$

In 2021, Adeli et al. evaluated the relationship between PCI and IRI indices for suburban routes using 600 km of roads in Fars province with $R^2=0.59$ to 0.76 for different types of roads.

A review of the research shows that the proposed models are based on limited databases only and do not show a wide range of IRI and PCI values. Since the use of these models for different roads is not reliable without considering the characteristics of the region, it is necessary to evaluate the proposed models to enable their use for roads in Iran. So in this study, data on PCI and IRI of five different freeways in Iran were studied and numerical models between these two parameters were reviewed and presented.

## 2. Data and Methodology

In line with the objectives of this study, IRI and PCI values measured for three freeways in Iran, that is, Tehran-Zanjan, Zanjan-Tabriz, and Kashan-Qom-Natanz, were collected. This data included PCI values for 500 m lengths and IRI values per 100 m road length. Therefore, in order to compare the IRI values with the PCI of the desired fragment, the average IRI of five consecutive data was considered as the representative value of that fragment (500 m). After modifying the input data using the models presented in previous studies, the values of the PCI index were predicted according to the measured value of the IRI index. Then, the accuracy of the predictions compared to the measured values of PCI index was calculated. The results showed that Equation 1 has a higher predictive accuracy than other relationships.

Since the process of construction and maintenance of pavements is different in different parts of the world, the process of pavement demolition, the type, and severity of damage in different roads can also be variable. Differences in the way pavement operations are performed, scheduling and different methods used in repair and maintenance, adherence to plans, financial resources, climatic conditions and topography of the region are among the effective parameters on how pavements are managed and maintained in different countries. Due to the special conditions of Iran in terms of topography, climate, and technology, it is expected that the process of road pavement demolition be different from other countries. Therefore, it can be expected that the predictions made using the proposed relations in other countries are not accurate enough for the Iranian roads. Therefore, to have an accurate prediction for Iran's roads pavement, we must provide an accurate model based on the conditions of pavements in Iran roads.

## 3. Results and Conclusion

According to the Iranian freeways pavement date used in this study, a 5 degree prediction model is proposed, which is presented in Equation 2.

$$PCI = -0.4609 \ IRI^5 + 8.691 \ IRI^4 - 61.26 \ IRI^3 + 199.4 \ IRI^2 - 319.8 \ IRI + 292.7 \quad (2)$$

Using the proposed relationship, PCI values were predicted according to the measured IRI value. The

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[1] Corresponding Author: Associate Professor, Department of Civil Engineering, Faculty of Engineering, Qom University of Azad University, South Branch, Tehran, Iran. **Email**: azim_hosseini@azad.ac.ir

[2] Ph.D. Student, Civil Engineering Department, Islamic Azad University

[3] Ph.D. Student, Faculty of Civil Engineering, Iran University of Science and Technology

[4] Ph.D. Department of Civil Engineering, Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran

[5] Assistant Professor, Department of Civil Engineering, Faculty of Engineering, Ferdowsi University of Mashhad, Mashhad, Iran

accuracy of the predictions is calculated by comparing the predicted PCI values to the measured PCI values. Results are presented in Table 1.

**Table 1: Accuracy of proposed predicting model for the modified data**

| Freeway Name | $R^2$ | MSE | σ |
|---|---|---|---|
| Tehran-Zanjan | 0.57 | 158.66 | 0.161 |
| Zanjan-Tehran | 0.63 | 171.96 | 0.176 |
| Zanjan-Tabriz | 0.51 | 217.99 | 0.240 |
| Tabriz-Zanjan | 0.57 | 196.64 | 0.202 |
| Kashan-Qom-Natanz | 0.71 | 233.80 | 0.256 |

As can be seen in Table 1, the values of the parameters of correlation coefficient, total errors, and standard deviation for different freeways are very close to each other, which shows the similar behavior in the pavement management system in the studied roads. On the other hand, the average value $R^2$ is approximately 0.60, which indicates the acceptable reliability coefficient of the predictions.

In general, the following important results were obtained:

- The results showed that the accuracy of measurement and data processing in Iran is low and the measured data requires careful control and modification;

- According to the results of the evaluations, it is not possible to use the relations provided in different parts of the world for the freeways in Iran. Specific conditions in each country, including regional characteristics and climatic conditions, the way of carrying out pavement operations, schedule and different methods used to repair and maintain pavement, the degree of adherence to programs, and financial resources cause differences in the quality of construction and maintenance of roads. Therefore, the trend of changes in the values of indices indicating the condition of pavement will be different in each country. This will make the indicators different from each other in different places and it will be necessary to conduct case studies for the existing roads in each region in order to determine the applied relationships with higher accuracy and reliability.

- Determining the value of PCI index using measured IRI values can be very useful and many efforts have been made in this regard, but studies show that there is no strong mathematical relationship between IRI and PCI indices. One of the most important reasons is that although the two indicators indicate the general condition of the pavement, due to the difference in the calculation method and the constituent parameters, it is not possible to establish a strong mathematical relationship between them. The PCI index includes longitudinal and transverse cracks, lizard skin cracks, and damage such as tarring that may not cause noticeable roughness at the pavement surface and therefore will not have a significant effect on the amount of IRI index. However, these failures can have a significant impact on the value of the PCI index. It is also possible that the amount of roughness in a piece of pavement is high but the pavement surface is free of cracking. In this case, the amount of unevenness has a significant effect on the value of the IRI index; If it will not have a significant effect on the value of the PCI index.

- A 5 degree prediction model was proposed in this study to predict PCI value from IRI value by average $R^2$ of 0.60 that means the model can be considered desirable and can be used in predicting conditions and decisions in pavement management in Iran.