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Predictive approach for post-covid 19 evolution study of the pavement surface deterioration based on visual inspection results

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ABSTRACT

This study proposes a statistical approach to examine pavement surface deterioration tendencies resulting from the COVID-19 pandemic. The road inspection results, the historical road databases, and the condition analysis make pavement management a major challenge for managers in Morocco as well as around the world. The decrease in traffic, the maintenance stoppages, the difficulties in obtaining field information, all these imperative ingredients are a consequence of the covid-19 pandemic. In this respect, historical analysis, remote monitoring and damage prediction have become increasingly important. In collaboration with the Moroccan National Center for Road Research, this study examines the impact of pandemic-induced lockup on the variation of three important pathologies: pullouts, cracks and potholes, based on the results of a visual inspection and the results of deflection and evenness performed in 2020 on a 50 km long section connecting Meknes and Khemisset cities. First, the reduction of data based on deterioration represented in four levels (A, B, C and D), second, the comparison of the different pathologies before and after the pandemic, the impact of the pandemic on the pavement quality, and finally, a prediction of the progression of the pathology using the linear regression method. This study will help decision makers to take into account pandemics and health failures in their pavement management approaches, and especially to prevent future damage for budget allocation.

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1. Introduction

Increased traffic on road networks causes pavement deterioration at a rapid rate, which significantly affects their performance. A road network in a good condition is essential for the traffic flow and the users' safety. The pavement surface deterioration can be represented by a surface indicator called: Pavement Index. To characterize the pavement condition, the several indexes have been developed and listed in the literature. Among these, we can mention the PSI (Present Serviceability Index) developed by Carey et al. (1960) [1], the ride quality has been considered a function of longitudinal pavement roughness. The PCI (Pavement Condition Index) established by Dronen (1982) [2], the RCI (Riding Comfort Index) developed by Karan (1983) [3], and the IRI (International Roughness Index) established by Sayers et al. (1986) [4]. This study

proposes an approach to the study of the surface deterioration [5] of a flexible pavement by means of a pavement performance indicator based on the Moroccan method [5] (see Table 1, Table 2, Table 3).

This research was initiated in order to contribute to the linear prediction of three surface deteriorations: potholes, pullouts and cracking, based on the results of visual inspections carried out on a 50 km long section. It is a question of reducing the data by matrixes of degradation relative to each level of deterioration, also to draw the tendency curves for the purpose to predict their evolutions. Finally, a synthesis of the future state of the studied section after the COVID-19 period.

2. Case study

The road section under study is part of the Moroccan national road number 06, over a length of 50 km and composed of a flexible structure. The choice of this section is argued by its necessity and

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Table 1
Matrix of the deterioration classification.

Deteriorations classes	Cracks (longitudinal and transversal)	Potholes	Pull-out
A	0	0	0-1
B	1-2	1	2-3
C	3-10	2-4	4-5
D	11-20	5-10	6-10

its geographical position, on the other hand, it is among the most solicited sections by heavy traffic. The last count carried out in 2020 confirmed the presence of 4777 AADT [6]. This reflects the

Table 2
Evenness classes.

(Evenness) Roughness index in mm/Km				
Evenness	T0	T1	T2	T3-T4
A	<2000	<2300	<3000	<3200
B	[2000,2500[[2300,2800[[3000,3500[[3200,3700[
C	[2500,3000[[2800,3300[[3500,4000[[3700,4200[
D	>=3000	>=3300	>=4000	>=4200

Table 3
Deflection classes.

Deflection en 1/100				
Class	T0	T1	T2	T3-T4
A	<80	<100	<120	<140
B	[80,120[[100,140[[120,160[[140,180[
C	>=120	>=140	>=160	>=180

importance of this road link that connects Meknes with Khemisset cities (see Fig. 1).

3. Methodology and materials

3.1. Method

The methodology of this study based on the analysis of the visual inspection results performed on the study section between the 2010 and 2020 years. The results are represented in the form of quantitative data for each kilometer studied. In order to reduce

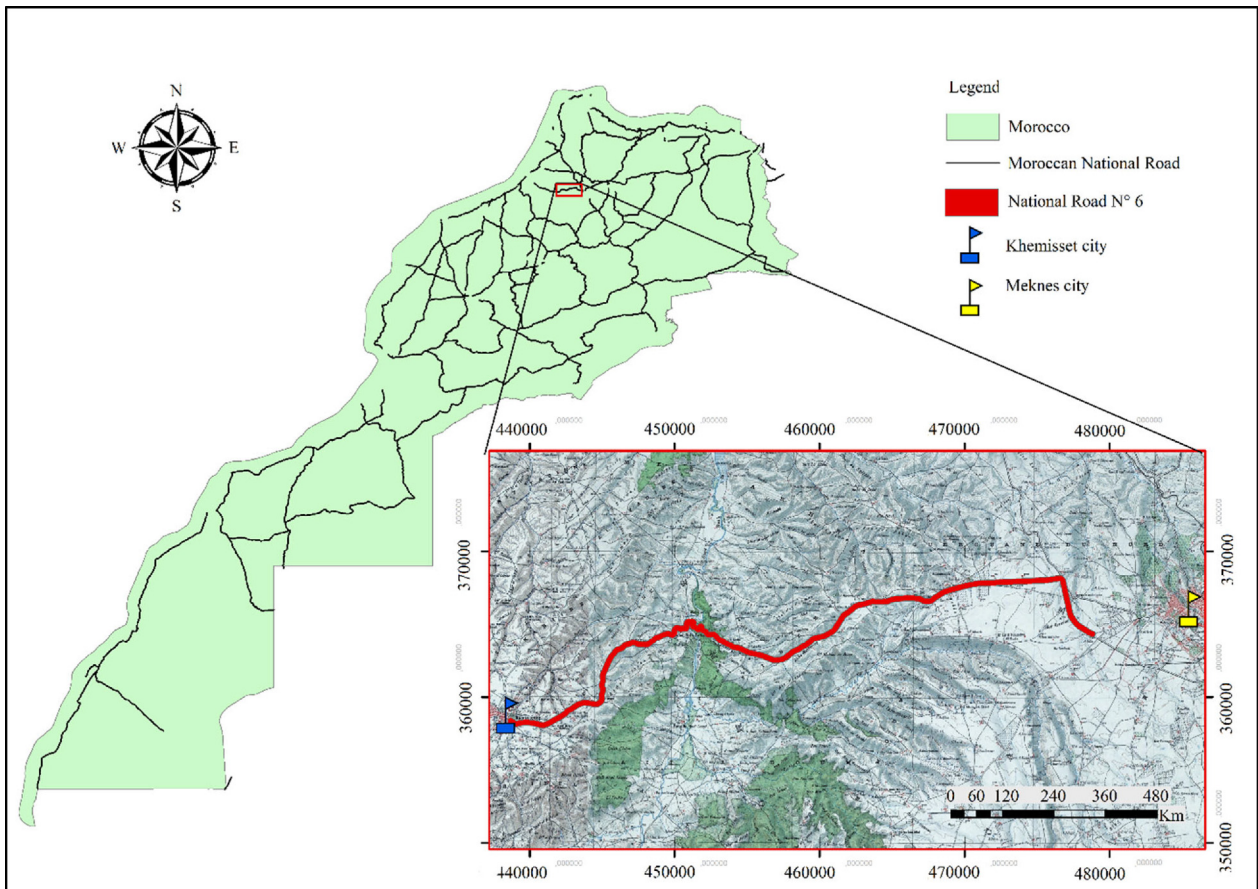


Fig. 1. Geolocation of case study.

the amount of data obtained, we applied the Moroccan method [7] for the classification of the deterioration state. This method is based on the visual and surveys analysis of the deterioration state on each 1 km length. This last one is carried out on 4 levels of degradation: A (Very good), B (Good), C (Bad) and D (Very bad). This classification is necessary for data reduction by the following matrixes:

3.2. Moroccan inspection method

The survey principle is based on the observation at regular intervals of 200 m of the existence or absence of each type of deterioration, indicating its severity (Fig. 10). The integration of the observations is done by adding up the scores given to each of the deteriorations (cracks, pull-outs and otholes) on each 1 km section.

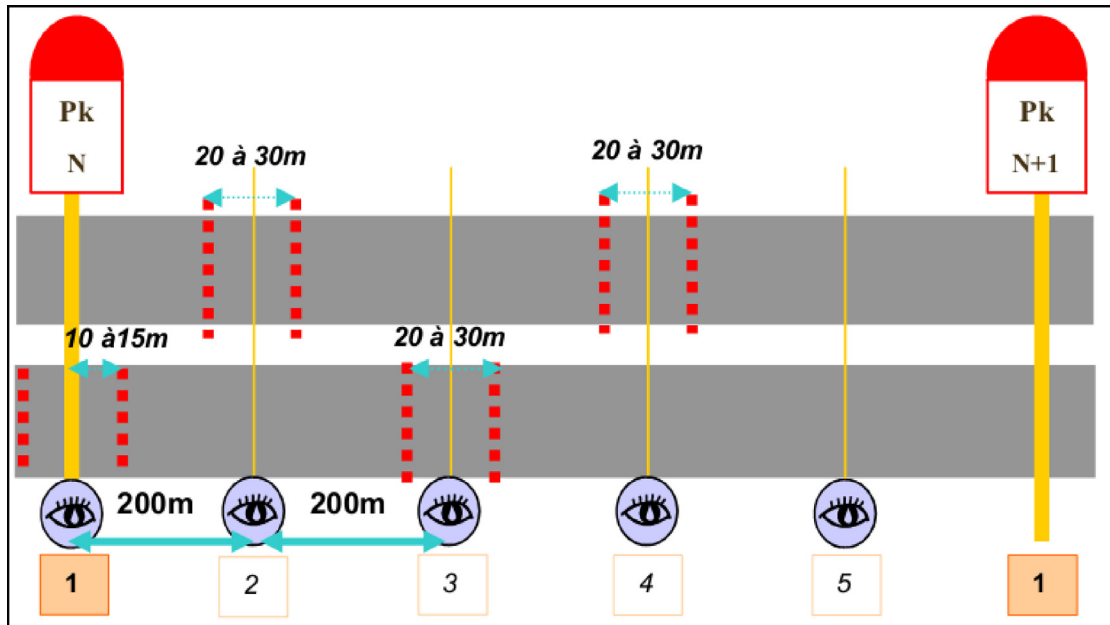


Fig. 2. Visual Moroccan inspection method.

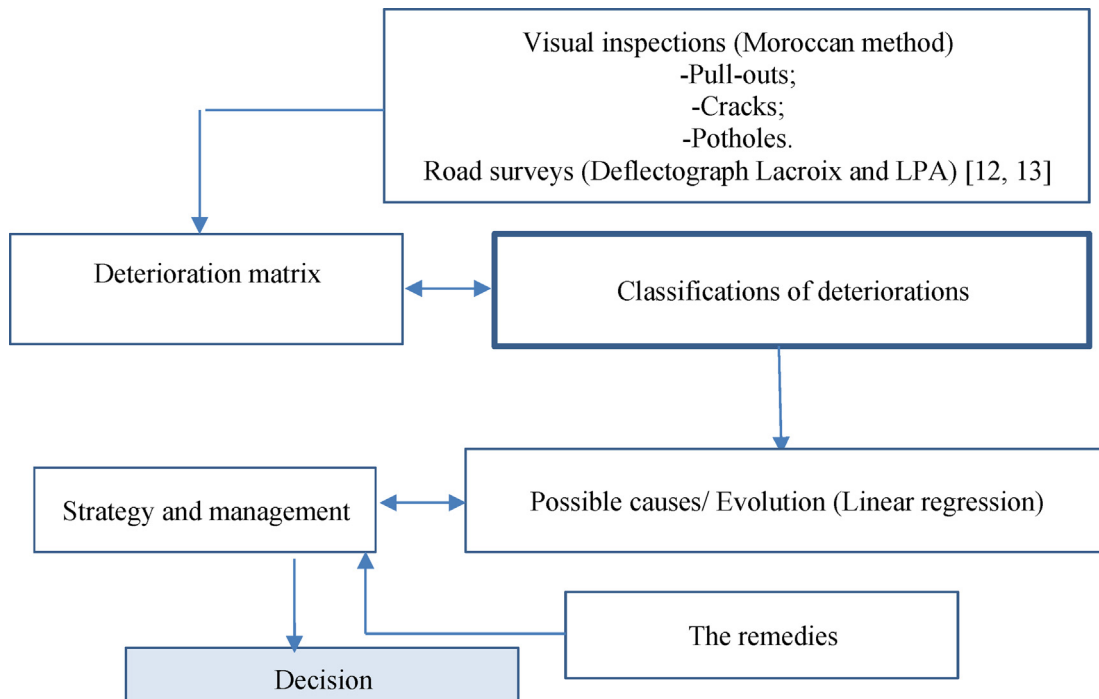


Fig. 3. Research significance.

For each km of pavement, the surface distress condition is classified into four classes for each distress according to the following decision grid, based on the cumulative scores over the km (see Fig. 2, Fig. 3, Fig. 4).

3.3. Forecasting evolution study

3.3.1. Linear regression (method)

Regression [8] is a technique used for two theories. First, regression analyses are generally used for forecasting and prediction, where their application largely overlaps with the field of machine

learning. Second, regression analysis can be used in some cases to determine causal relations between independent and dependent variables. It is important to note that regressions. Only show relations between a dependent variable and a fixed data set of different variables.

The results of the data reduction by the matrices were processed by the linear regression method [...]. The purpose of simple regression is to explain the deformations as a function of time. The variable Y (Deformation) is called dependent variable, or variable to be explained and the variables Xj (j = 1, ..., q) are called independent variables (time), or explanatory variables. To study the pre-

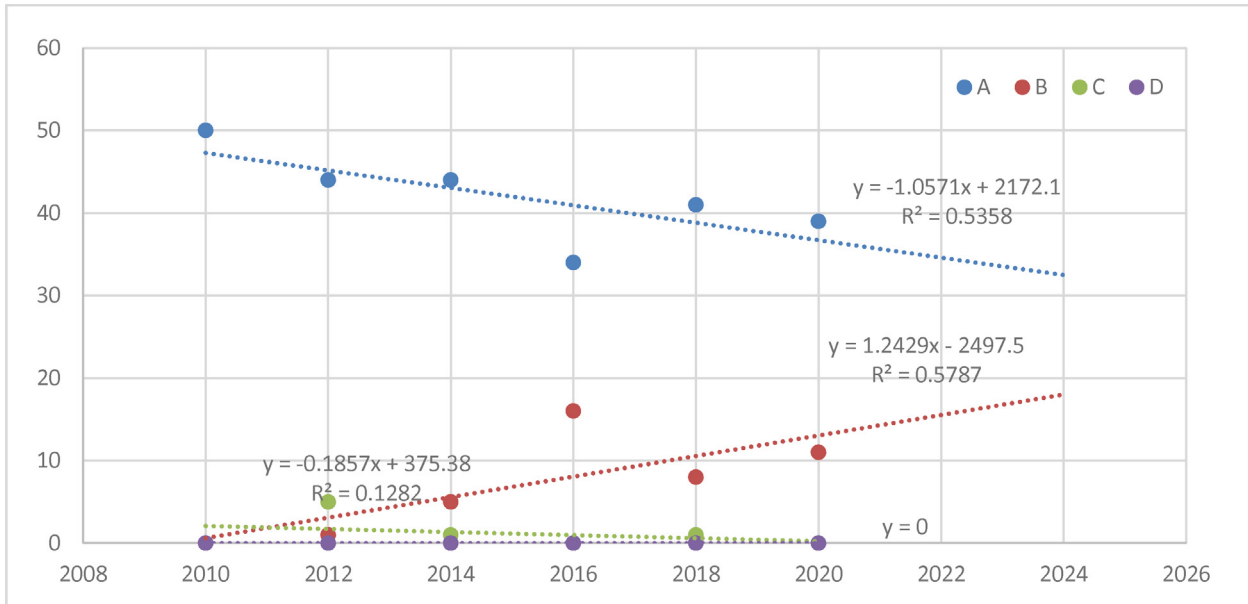


Fig. 4. Tendency curves of cracking.

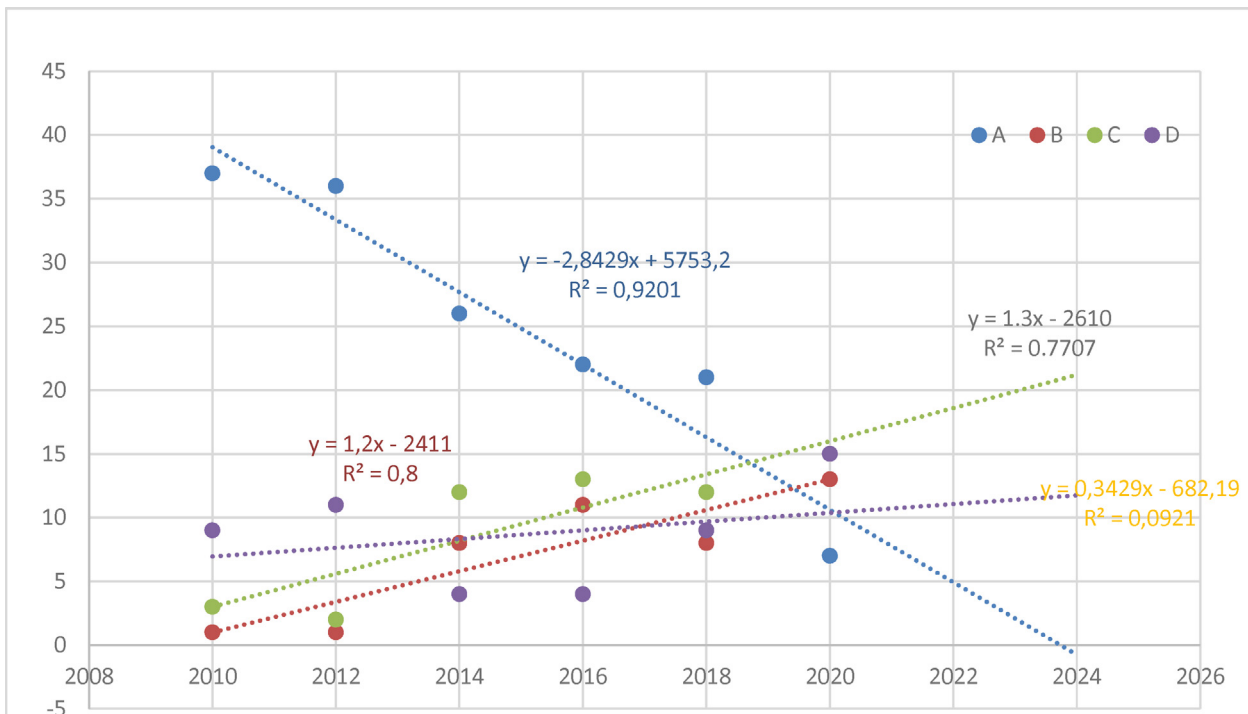


Fig. 5. Tendency curves of pull-out.

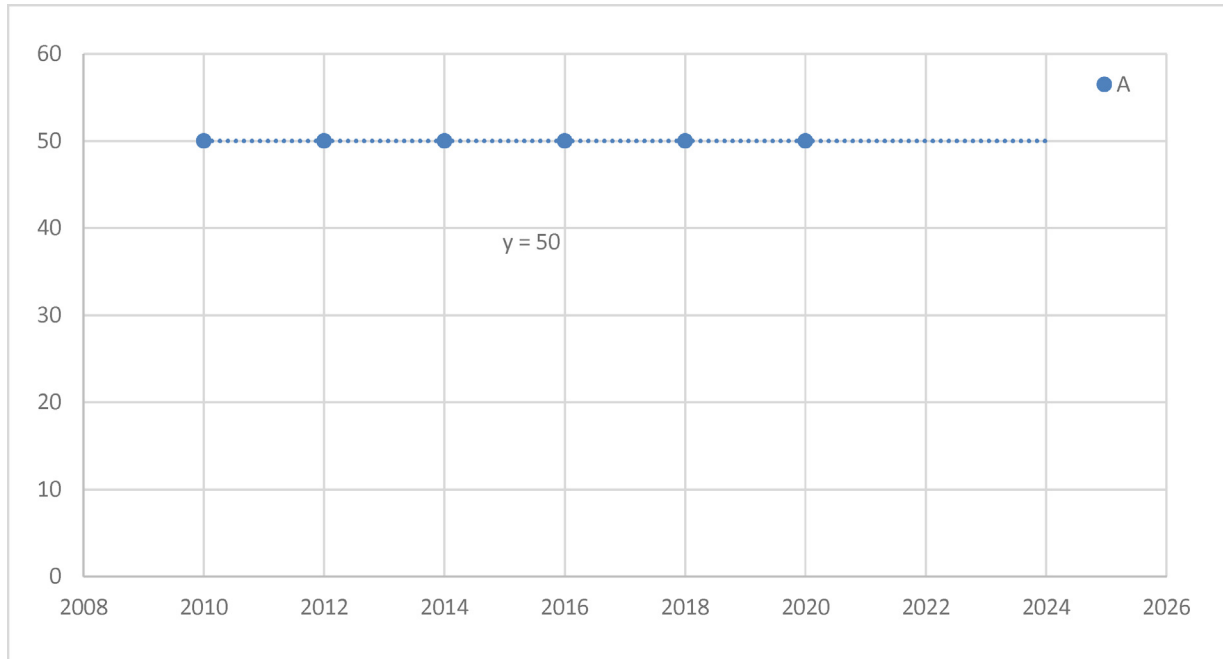


Fig. 6. Tendency curves of potholes.

dictive evolution of each pathology studied in function of its state of degradation, we could draw the rights of adjustment of each level of degradation by the method of the least squares [9].

3.4. Research significance:

The methodology adapted in this article are represented in the following figure:

4. Results and discussion

The results obtained are related to the analysis of data from visual inspections carried out on the section under study (2010–2020). The equations of tendency obtained from the three pathologies are represented in the following figures.

Analyzing the study section evolution, the deteriorations have several changes over the last 10 years (between 2010 and 2020). The results related to pullouts (Fig. 5) reflect a negative trend of the state level (A) with a negative directional coefficient (-2.8429), leading to a fall in quality in the post-Covid 19 period (after 2020). On the other hand a positive trend of deterioration state (B, C and D), with positive coefficients, resulting in a decrease of quality in the next years. The potholes (Fig. 6) have a stable stability along this period in view of the maintenance actions and the upkeep, with a stable linear function equal to: $Y = 50$. The predictive significance tends to the stability of this type of deformation in the highly satisfactory state (A). Regarding the cracks condition (Fig. 7), the plotted functions show a negative trend of the degradation condition A, with a negative coefficient of value: $-1, 0057$. On the other hand, an increase of the deterioration state B with a positive coefficient of value: $1, 2429$. In contrast, a stability of the state of degradation D ($Y = 0$) and a decrease of the deterioration state C with a negative coefficient of value -0.1857 , which show the possibility of the decrease of the surface deterioration state of this pavement (see Fig. 8, Fig. 9, Fig. 10).

4.1. Post-Covid 19 period: recommendations

Regrouping the three levels of deterioration, a negative trend of the A condition related to the pullouts and cracking leads to confirm the decrease of the pavement performance condition in the period of Covid-19, in spite of the traffic level decrease. Moreover,



Fig. 7. Deflectograph Lacroix measurement [12].



Fig. 8. Longitudinal Profil Analyzer measurement [13].

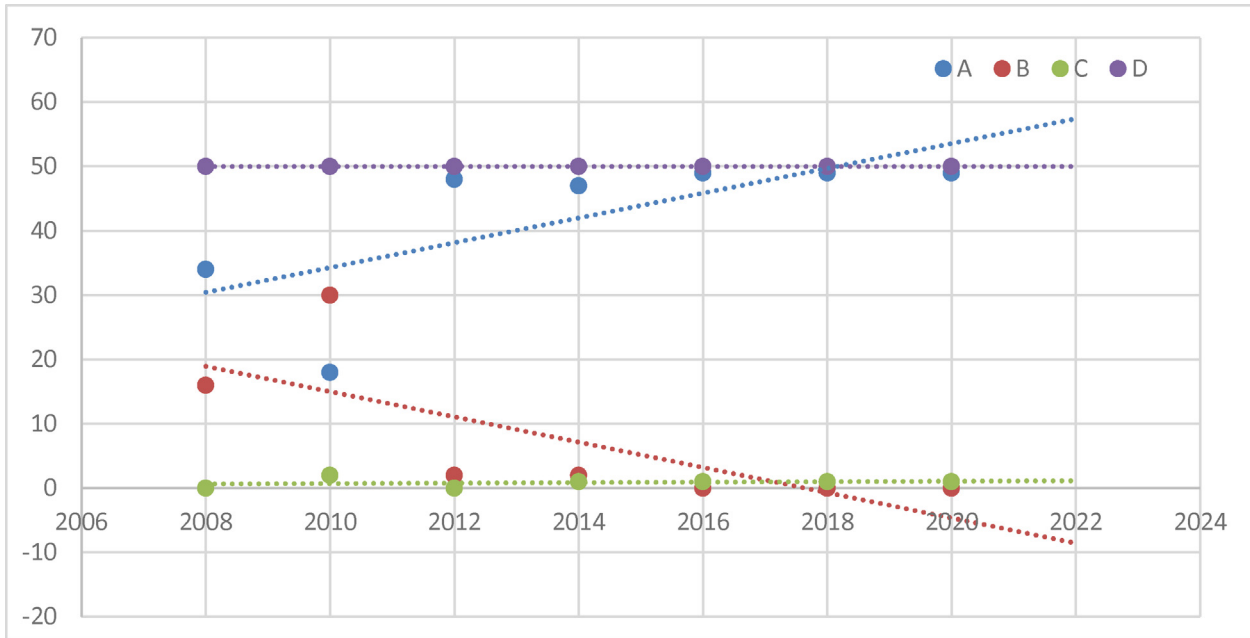


Fig. 9. Deflection results.

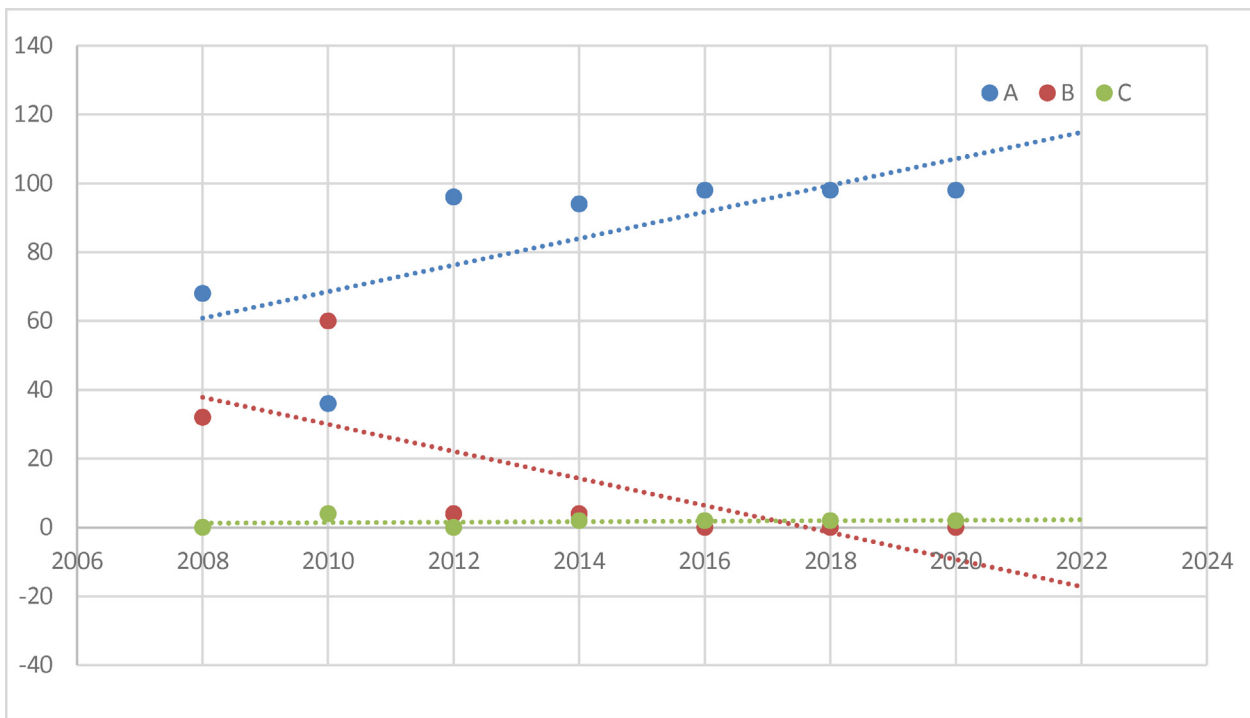


Fig. 10. Evenness results.

to keep the stability of the potholes, the A level will be ensured if the cracks and pullouts are maintained and repaired, keeping a good ratio of A + B for both types of deformations.

In view of the absence of any maintenance actions since the beginning of the period ovid-19, the pavement has experienced a decrease in its surface condition and precisely in its quality offered to users. In addition, the predictions made confirm the pathologies tendency towards the increase in the next years. We propose the following actions to maintain the surface condition of this pavement:

- Replacing the cracked layers with cover layers [10];
- Filling of cracks to prevent further deterioration [11];
- Correction of full depth pull-outs [11].

4.2. Pavement structural analysis

The pavement deflection and evenness results are obtained from the auscultation tests using the Lacroix Deflectograph and the Longitudinal Profile Analyzer (LPA). The objective of these tests is to measure the pavement bearing capacity of a road network and

to detect defective areas to be reinforced. In addition, the pavement structural regularity analysis [14]. The quantitative results obtained have been classified by the following deterioration matrixes:

The figures below represent the two measurement materials used for the determination of the pavement deflections and evenness:

The deflection and evenness results are represented in the following figures:

4.3. Comparing the pavement surface and structural results

The results of the deflection obtained show a positive tendency of the indicator A (very good condition), a decrease in the B condition (good condition), with a certain stability of C and D (bad to very bad). For the pavement evenness, the indicator of level A showed a positive progression with a decrease of B and stability of C. The variation of pavement deflection and evenness reflects the structural condition stability. In contrast, the pavement surface condition showed a weakness represented by the negative trend of the A values for pullouts and cracks, which appears normal given the decrease in activity during COVID 19 period and the reduction in traffic along this stretch.

The structural condition is considered stable during the Covid-19 period, which gives an overall idea of the bearing capacity and durability of this pavement. However, the decrease in the surface condition leads the road manager to think about the necessary maintenance actions. The absence of the latter can lead to potholes which will automatically impact the structural condition of this pavement.

5. Conclusion et perspectives

Road data collection tools and visual surveys are only as good as the people who use them. The survey quality depends on a perfect control of the road pavement quality, on the one hand, but also on the evaluation of their severity degree.

A road network presents a great diversity of structure and materials combinations which composition, implementation and age will influence the pavement behavior. In addition, not all sections of a network are subjected to the same stresses: traffic loads and local climatic conditions as well as the geometric situation may differ. In view of the pandemic situation, our study has been limited to the analysis of the surface deterioration evolution while not taking into account the verification of the structural deformations.

Given the pandemic situation, our study was limited to the analysis of the evolution of the surface deterioration in view of comparing it with the structural one. In this respect, our study can be opened to the following perspectives:

- -Study of the scenarios of possible maintenance interventions,
- -Proposal of a new pavement management tool through the introduction of geographic information systems,

- -Localization of temporal degradations through the analysis of satellite images.

CRedit authorship contribution statement

M.A. Mehdi: Conceptualization, Data curation, Formal analysis, Methodology. **T. Cherradi:** Conceptualization, Formal analysis, Methodology. **A. Bouyahyaoui:** Conceptualization, Formal analysis, Methodology. **S. El Karkouri:** Data curation. **M. Qachar:** Data curation.

Data availability

The data that has been used is confidential.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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