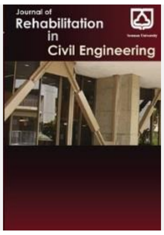

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Falling Weight Deflectometer Test Oriented Overlay Thickness Design: Case Study

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ABSTRACT

Falling Weight Deflectometer (FWD) can evaluate the assessment of structural conditions of pavements that require rehabilitation. Fifteen different pavement sections have been selected that six sections have located in Qom-Kashan Freeway, Iran and nine sections have located in Kashan-Qom Freeway, Iran to conduct FWD tests. FWD data have been analyzed to determine and monitor the structural adequacies of existing pavement sections includes the pavement deflection and load chart, the average deflection chart of seven geophones, and the calculated overlay thickness diagram for each station of each section. The results indicate that the average deflection for Direction: Qom-Kashan, is 6.7% less than Direction: Kashan-Qom. In this paper, the structural conditions of existing pavements have been assessed, and subsequently required overlay thickness values have been recommended from critical pavement responses computed from FWD field deflections. The results indicate that the surface of the pavement for Direction: Kashan-Qom needs 6.1% more overlay thickness than Direction: Qom-Kashan. Also, the Structural Condition Index (SCI) that is widely used on network and preliminary project level investigations has been calculated. Furthermore, a comparison is presented between calculated SCI before and after applying overlay and the effect of this index value on the pavement performance.

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1. Introduction

AASHTO design guide [1] has been used for the pavement structure design. This guide has been considered the influence of important changes in asphalt technology such as the addition of modifiers, recycled asphalt, and changes in climatic condition and traffic investigated the concept of structural number (SN).

Falling Weight Deflectometer (FWD) test has been applied to evaluate the in-situ asphalt pavement structures and layer properties of pavement as a non-destructive test [2–5]. The FWD loading is essentially impulse loading and can make a wide range of frequencies. Using the load element method, FWD deflections can be measured for asphalt pavements with different load histories [6–10]. Also, FWD testing is one of the several methods for determining the stiffness of asphalt concrete in an existing pavement. Bech and Vandenbossche [11] have investigated the differences between determining asphalt concrete stiffness methods and the effects of FWD load magnitude and asphalt. They have concluded that both FWD load magnitude and asphalt temperature have a significant effect on the estimated stiffness of asphalt concrete [12,13].

Durability and increasing the service life of existing pavements is a significant purpose in pavement performance evaluation and pavement management [14–18]. Applying the non-destructive test is an important tool for in-service pavement structural evaluation [19–22].

FWD can use to assess the structural conditions of flexible pavements that need rehabilitation and maintenance. One of the most common structural improvements of pavements involves applying the placement of asphalt overlay as the maintenance and rehabilitation approach for flexible pavements. Using the non-destructive testing equipment such as FWD can investigate the structural condition of existing pavement and determine the pavement requirement to overlay [23–26].

Structural number (SN) method comes on American Association of State Highway Officials (AASHO) road tests basis [27,28].

This research has been produced on the use of FWD technology for the evaluation of Qom-Kashan Freeway, Iran. The objective of this study is to overlay the thickness calculation of in-service pavements based on the back-calculated layer moduli as predicted from FWD testing. To achieve this objective, FWD data were used in a back-calculation process; the back-calculated moduli were then correlated and categorized statistically to establish elastic parameters describe excellent structural conditions of the pavement structure. Pavement structural conditions can be described with the help of overlay thickness and based on FWD measurements and appropriate selection strategies.

An overview of the framework for this study is presented in Fig. 1.

2. Methodology

2.1. Case study definition

The FWD system was trialed on 6.7 km of section 1, 3.1 km of section 2, 10.9 km of section 3, 2.8 km of section 4, 1.2 km of section 5, 1.8 km of section 6 of the direction of Qom-Kashan Freeway, and 1.3 km of section 1, 1.0 km of section 2, 0.6 km of section 3, 1.6 km of section 4, 5.2 km of section 5, 8.0 km of section 6, 3.1 km of section 7, 2.1 km of section 8, 0.6 km of section 9 of the direction of Kashan-Qom Freeway in the southeast portion the province of Qom and northwest portion the province of Esfahan, Iran (Fig. 2).

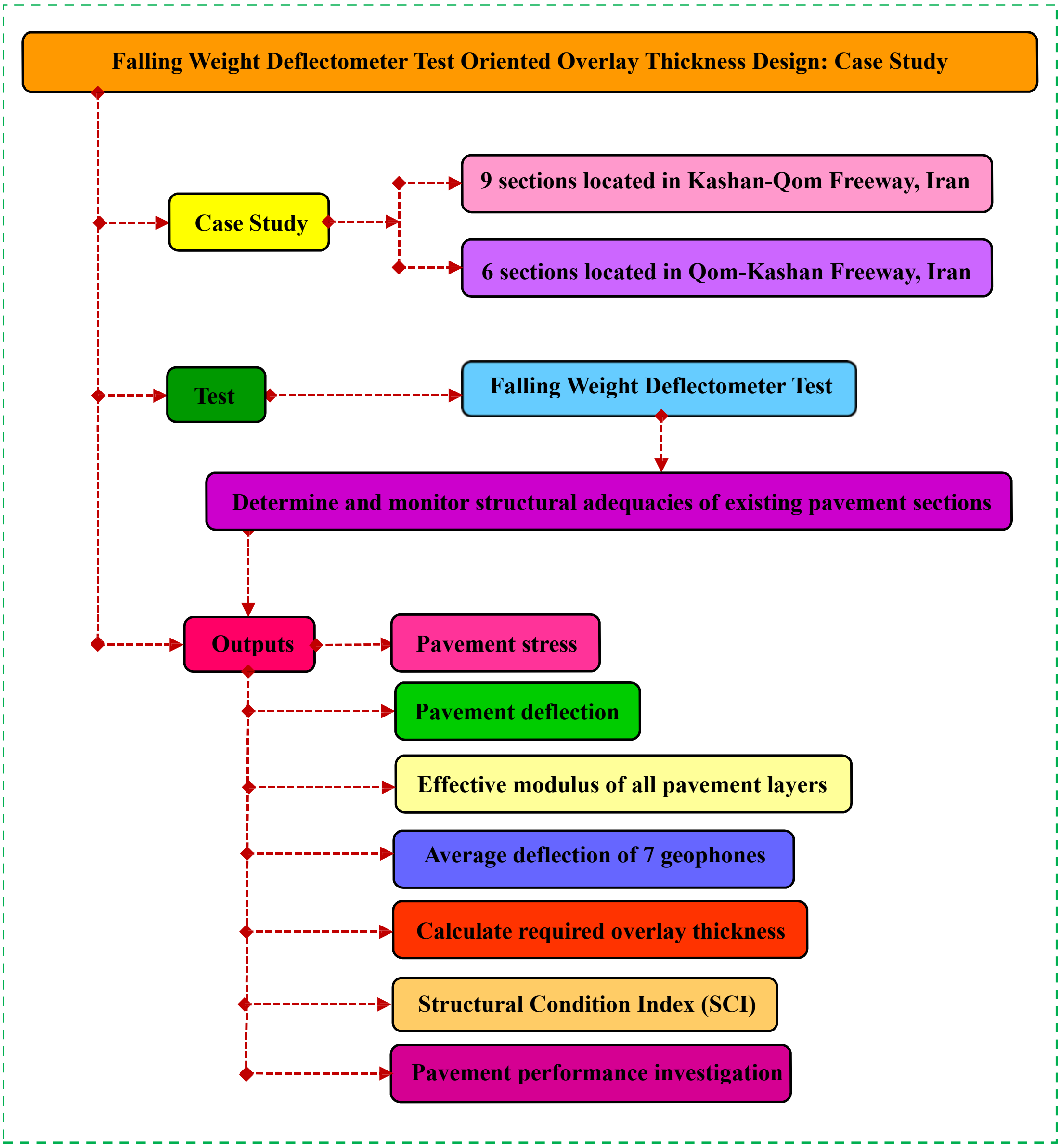

Fig. 1. Framework of this paper.

Fig. 2. Location of Kashan-Qom Freeway in the southeast portion of the province of Qom and northwest portion of the province of Esfahan, Iran.

2.2. FWD System

The FWD device is one of the non-destructive devices used in the evaluation of road pavement structures. This device measures the amount of drop and its intensity with the help of geophones by applying the same stress as the wheel axle load of 8.2 tons to the pavement in a period of 10 to 35 milliseconds. The device is also able to automatically measure and record the air temperature and asphalt surface temperature. Measuring the deflection responses with the FWD device is done according to Fig. 3 in selected local road pavement sections. Table 1 indicates that the operational plan of measuring the deflection responses with the FWD device.

(a)

(b)

(c)

Fig. 3. (a) FWD device; (b), (c) Conducting FWD tests in selected local road pavement sections.

Table 1. Operational plan of measuring the deflection responses with FWD device.

Parameter	Value
Applied Stress (kPa)	600-900-1300
Plate Radius (mm)	150
Number of Weight Falling	3
Number of Geophones	7
Configuration of Geophones (cm)	0-30-60-90-120-150-180
The distance of Tests (m)	200
Test Line	on the slow driving line and at a distance of 60 cm from the sideline

Details of the proposed sections for FWD tests are shown in Table 2.

Table 2. Details of the proposed sections for FWD tests.

Direction	Section	Start*	End*	Length	Location Coordinate (GPS)				Thickness		10years of Traffic
					Start		End		Asphalt	Base & Subbase	8.2-ton Equivalent Axis
		km	km	km	N	E	N	E	mm	mm	
Qom-Kashan	1	31.3	38.0	6.7	34.4538433	51.10306	34.42392	51.16699	200	300	34117558
	2	44.1	47.2	3.1	34.3864583	51.21514	34.36869	51.24099	200	300	34117558
	3	50.7	61.6	10.9	34.3440583	51.2645	34.25284	51.25645	200	300	34117558
	4	80.6	83.4	2.8	34.0923083	51.30823	34.0672	51.3098	153	300	34117558
	5	86.7	87.9	1.2	34.0382533	51.31778	34.02823	51.32254	250	300	34117558
	6	95.6	97.4	1.8	33.9636084	51.34871	33.95198	51.36217	250	300	34117558
Kashan-Qom	1	97.4	96.1	1.3	33.952395	51.3621	33.96074	51.35216	250	300	34117558
	2	79.0	78.0	1.0	34.1065833	51.30347	34.11422	51.29809	250	300	34117558
	3	70.9	70.3	0.6	34.1679817	51.26101	34.17392	51.25858	250	300	34117558
	4	69.7	68.0	1.6	34.1783217	51.25733	34.19349	51.25617	250	300	34117558
	5	49.4	44.0	5.2	34.35192	51.25744	34.38602	51.21627	230	300	34117558
	6	30.0	22.0	8.0	34.458755	51.09486	34.50657	51.03076	250	300	34117558
	7	17.4	14.3	3.1	34.54628	51.01457	34.56574	50.9897	170	300	34117558
	8	11.4	9.3	2.1	34.5869733	50.9704	34.60439	50.96002	170	300	34117558
	9	6.4	5.8	0.6	34.62813	50.94645	34.63322	50.94401	260	300	34117558

2.3. Overlay thickness design

The overlay is designed to increase the load-bearing capacity of pavement. By applying the overlay, the pavement load capacity of the predicted traffic increases. Eq. 1 is used to determine the overlay structural number [27].

$$SN_{ol} = SN_{req} - SN_{eff} \tag{1}$$

where SN_{ol} is the overlay structural number, SN_{req} is the required structural number of the new pavement, and SN_{eff} is the effective structural number of the existing pavement.

The effective structural number of the existing pavement (SN_{eff}) can be calculated in two ways:

(i) Non-destructive method using impact results (FWD)

(ii) Evaluation method of existing pavement layers

To determine the effective structural number of the existing pavement by applying the FWD method, the following steps must be performed:

2.3.1. Calculate subgrade resilient modulus (M_r)

This coefficient is calculated using Eq. 2 [27]:

$$M_r = \frac{0.24P}{rd_r} \quad (2)$$

where M_r is the subgrade resilient modulus in psi, $P$is applied load in-lb, r is the radial distance that the deflections are measured in inch, and d_r is measured deflection at a radial distance r from the load in inch.

To design the asphalt pavement, the subgrade resilient modulus should be used, which is calculated from Eq. 3 [27]:

$$M_R = C\left(\frac{0.24P}{rd_r}\right) \quad (3)$$

where, M_R is the subgrade design resilient modulus in psi, and C is a coefficient with a max value of 0.33.

To calculate the subgrade design resilient modulus, the geophone that recorded the deflection of the pavement (d_r) should be determined, which is calculated by trial and error using Eq. 4 and Eq. 5 [27]:

$$r \geq 0.7a_e \quad (4)$$

$$a_e = \sqrt{\left[a^2 + \left(D \times \sqrt[3]{\frac{E_p}{M_r}}\right)^2\right]} \quad (5)$$

where a_e is the stress effect radius on subgrade in inch, a is the radius of loading plate in inch, E_p is the effective modulus of all pavement layers up to the subgrade in psi, and D is the total thickness of the pavement layers up to the subgrade in inch, according to Eq. 6 [27].

$$D = D_{AC} + D_{BS} \quad (6)$$

where $D_{AC}$is the thickness of the asphalt pavement layer and D_{BS} is the thickness of the base layer.

2.3.2. Calculate effective modulus (E_p)

The value of the effective modulus of all pavement layers (E_p) is obtained according to the deflection in the center of the loading plate of Eq. 7 [27].

$$d_0 = 1.5pa\left(\frac{1}{M_r\sqrt{1+\left(\frac{D}{a}\sqrt[3]{\frac{E_p}{M_r}}\right)^2}} + \frac{\left[1-\frac{1}{\sqrt{1+\left(\frac{D}{a}\right)^2}}\right]}{E_p}\right) \quad (7)$$

where d_0 is deflection in the center of the loading plate (modified for $20\ ^\circ C$) in inch, p is stress in the loading plate in psi, and M_r is the subgrade resilient modulus in psi.

Changing the ambient temperature affects the measured deflection of pavement in the center of the loading plate, for example, increasing the temperature of the asphalt surface increases deflection. So, different climatic conditions must convert to standard conditions with $20\ ^\circ C$ ($68\ ^\circ F$) temperature. Correction of pavement deflections in the center of the loading plate is done by using Fig. 4.

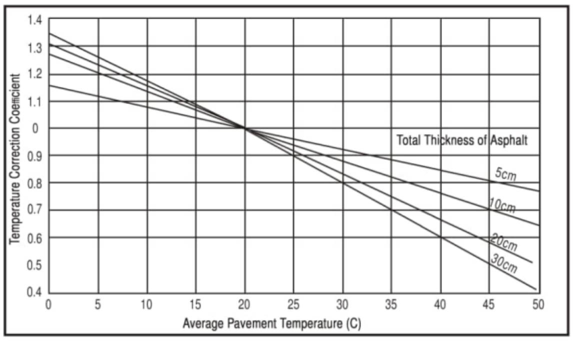

Fig. 4. Temperature correction coefficient.

2.3.3. Calculate effective structural number (SN_{eff})

The number of effective pavement structures (SN_{eff}) is obtained from Eq. 8 [27].

$$SN_{eff} = 0.0045D\sqrt[3]{E_p} \tag{8}$$

2.3.4. Calculate required structural number (SN_{req})

The total structural number of pavement without considering the existing pavement structure and as a new pavement for the traffic passing through the overlay design period and based on the subgrade design resilient modulus is calculated by Eq. 9 [27].

$$log\,W_{8.2} = Z_R S_0 + 9.36\,log(SN_{req} + 1) -0.2 + \frac{log\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.4+\frac{1094}{(SN_{req}+1)^{5.19}}} + 2.32\,log\,M_R - 8.07 \tag{9}$$

where, SN_{req} is the new pavement required structural number, $W_{8.2}$ is equal to 8.2 ton, Z_R is standard normal deviate, S_0 is the overall standard deviation, ΔPSI is allowable serviceability loss, andM_R is the resilient modulus of subgrade.

2.3.5. Calculate overlay thickness (D_{ol})

By determining the overlay structural number (SN_{ol}) by Eq. 1, the overlay thickness is determined according to Eq. 10.

$$D_{ol} = 2.5\left(\frac{SN_{ol}}{a_{ol}}\right) \tag{10}$$

where, $D_{ol}$is the overlay thickness in cm, and a_{ol} is the overlay coefficient equals to 0.44.

Structural Condition Index (SCI) as screening tools for decisions regarding maintenance and rehabilitation is determined according to Eq. 11.

$$SCI = \frac{SN_{eff}}{SN_{req}} \tag{11}$$

where, SCI is Structural Condition Index, SN_{eff} is the number of effective pavement structures, SN_{req} is the required structural number of the new pavement, typically calculated as needed for the design period based on known material qualities and thicknesses [29,30].

3. Result and discussion

The falling weight deflectometer (FWD) has taken over as the preferred deflection measuring device for rehabilitation of pavement and overlay design. The non-destructive tests are inexpensive and fast to obtain graphical results of pavement design. However, the destructive tests to the pavement designing process are very time-consuming. Thus, applying the non-destructive test such as the FWD test can be effective in slower destruction of pavement layers.

In this research, the details of the FWD in the proposed sections of Amirkabir Freeway (Qom- Kashan Freeway) are presented for two directions: Qom- Kashan, and Kashan- Qom, according to Table 2. FWD data analysis that is as follows includes the pavement deflection and load chart at 900 kPa stress level for each station of each section, the average deflection chart of seven geophones for each station of each section, and the calculated overlay thickness diagram for each station of each section.

As indicated in Fig. 5, Qom- Kashan Freeway is part of Tehran- Bandar Abbas Freeway. Bandar Abbas is a city located in the south side of Iran that Bandar Abbas is the most active port for goods transit. Because of its suitable possibilities for loading and unloading goods that have allocated the lion share in the country's transit. Thus, heavy vehicles include trucks and trailers, and containers that move from Tehran to Bandar Abbas, are loaded in Bandar Abbas and return. Due to the loading of heavy vehicles, the backline or Bandar Abbas- Tehran Freeway is more vulnerable to damage. The results of non-destructive tests indicate this reality. So, this freeway located in the Kashan-Qom direction suffers more damage than Qom-Kashan direction.

Fig. 5. Location of Tehran-Bandar Abbas Freeway, Iran.

Table 3 and Table 4 present the required data for the calculation by Eq. (1) to Eq. (11) for Direction: Qom- Kashan, Section: 2 and Direction: Kashan- Qom, Section: 5, respectively.

Table 3. Required data for calculation for Direction: Qom- Kashan, Section: 2.

Station*	Stress	Load	Temp	Coefficient	d_0	d_{0mod}	d_r	D_{AC}	D_{BS}
(km)	(kPa)	(kN)	ºC	(-)	(micron)	(micron)	(micron)	(cm)	(cm)
44.1	827	58.5	13.4	1.1	486	536	140	20	30
44.4	831	58.7	13.3	1.1	446	492	149	20	30
44.5	843	59.6	13.7	1.1	518	569	123	20	30
44.7	841	59.4	13.5	1.1	462	509	134	20	30
44.8	815	57.6	13.6	1.1	715	786	102	20	30
45	839	59.3	13.4	1.1	559	616	159	20	30
45.2	838	59.2	13.7	1.1	462	507	134	20	30
45.4	833	58.9	13.5	1.1	502	553	170	20	30
45.6	838	59.2	13.7	1.1	493	541	159	20	30
45.8	827	58.5	14.2	1.09	606	661	156	20	30
46	821	58	13.3	1.1	504	556	135	20	30
46.2	845	59.7	13.9	1.09	490	536	156	20	30
46.4	829	58.6	13.8	1.1	597	655	136	20	30
46.6	828	58.5	13.7	1.1	494	542	160	20	30
46.8	845	59.7	14.1	1.09	562	613	148	20	30
47	824	58.2	13.8	1.1	568	623	115	20	30

* FWD kilometers are considered from Qom.

Table 4. Required data for calculation for Direction: Kashan- Qom, Section: 5.

Station*	Stress	Load	Temp	Coefficient	d_0	d_{0mod}	d_r	D_{AC}	D_{BS}
(km)	(kPa)	(kN)	ºC	(-)	(micron)	(micron)	(micron)	(cm)	(cm)
44	830	58.7	13.6	1.1	557	614	174	23	30
44.2	811	57.3	13.2	1.11	788	873	113	23	30
44.4	841	59.4	13.5	1.1	549	605	136	23	30
44.6	837	59.2	13.5	1.1	532	586	169	23	30
44.8	820	58	13.5	1.1	596	658	174	23	30
45	836	59.1	13.6	1.1	502	553	163	23	30
45.2	809	57.2	13.6	1.1	974	1073	105	23	30
45.4	825	58.3	13.6	1.1	665	733	173	23	30
45.6	835	59	13.7	1.1	683	751	190	23	30
45.7	849	60	13.8	1.1	642	705	163	23	30
46	835	59	14.2	1.09	604	660	144	23	30
46.2	823	58.2	14.2	1.09	637	695	169	23	30
46.4	838	59.2	14.3	1.09	548	598	162	23	30
46.6	824	58.2	14.4	1.09	686	747	130	23	30
46.8	830	58.7	14.3	1.09	651	710	109	23	30
47	842	59.5	14.4	1.09	457	497	155	23	30
47.2	838	59.2	14.3	1.09	470	512	162	23	30
47.4	845	59.7	14.3	1.09	640	698	136	23	30
47.6	837	59.2	14.4	1.09	452	492	139	23	30
47.8	819	57.9	14.4	1.09	788	857	162	23	30
48	841	59.4	14.7	1.08	364	394	118	23	30
48.2	836	59.1	14.7	1.08	568	615	103	23	30
48.4	900	63.6	14.8	1.08	455	492	132	23	30
48.6	839	59.3	14.7	1.08	426	462	104	23	30
48.8	839	59.3	14.9	1.08	390	421	147	23	30
49	836	59.1	14.8	1.08	300	325	80	23	30

* FWD kilometers are considered from Qom.

Fig. 6 and Fig. 7 indicate the pavement deflection and load chart at 900 kPa stress level for seven geophones for Direction: Qom- Kashan, Section: 2, and Direction: Kashan- Qom, Section: 5, respectively.

As shown in Fig. 6 and Fig. 7, the left vertical axis indicates deflection values for seven geophones in Microns for Direction: Qom- Kashan, Section: 2, and Direction: Kashan- Qom, Section: 5, respectively. Also, in Fig. 6 and Fig. 7, the right vertical axis indicates the stress values in kPa for Direction: Qom- Kashan, Section: 2, and Direction: Kashan- Qom, Section: 5, respectively.

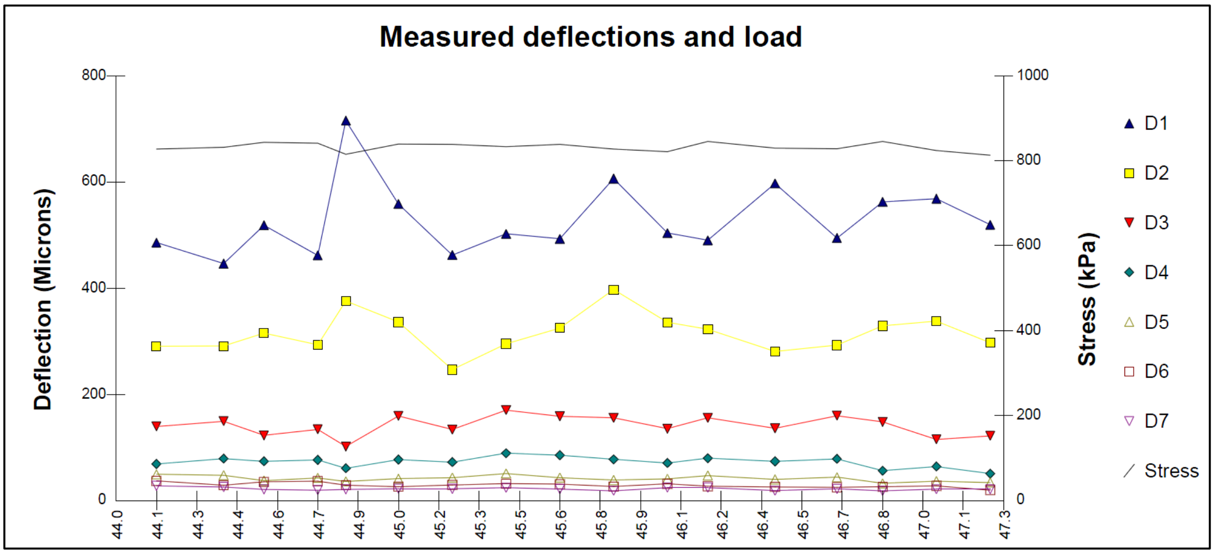

Fig. 6. Pavement deflection and load chart at 900 kPa stress level for Direction: Qom- Kashan, Section: 2.

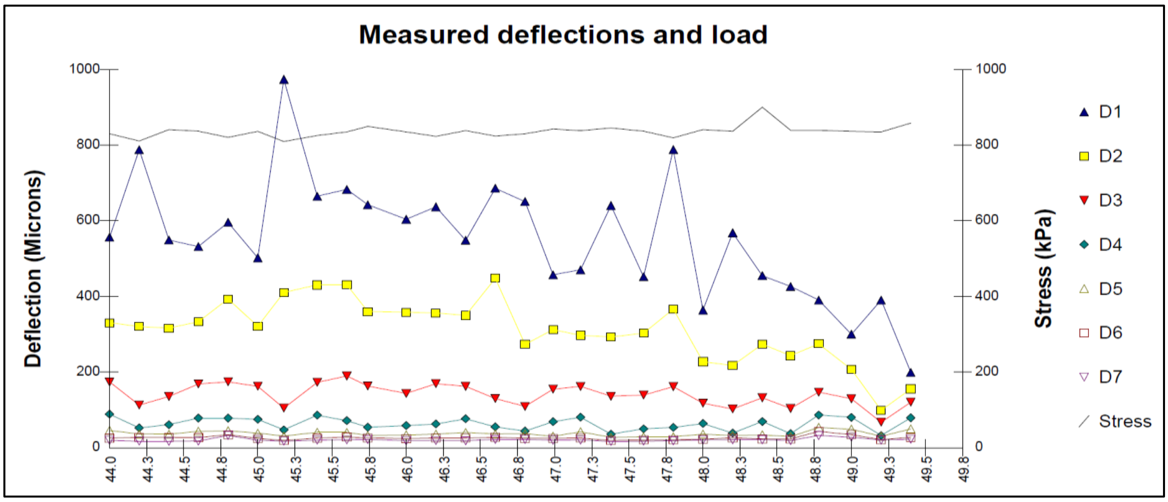

Fig. 7. Pavement deflection and load chart at 900 kPa stress level for Direction: Kashan- Qom, Section: 5The average deflection charts of seven geophones for Direction: Qom- Kashan, Section: 2, and Direction: Kashan-Qom, Section: 5 are compared in Fig. 8.

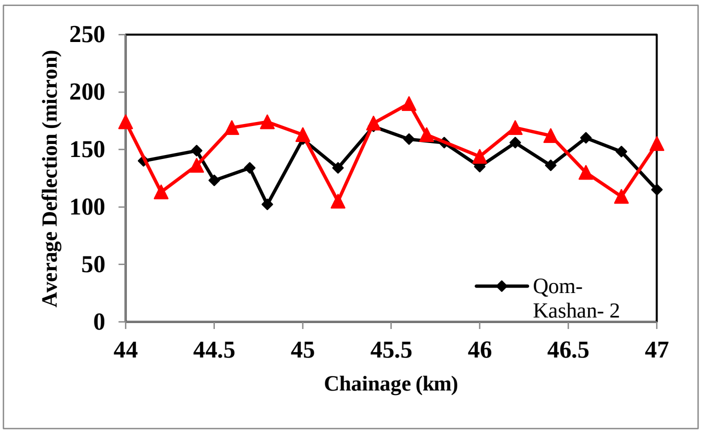

Fig. 8. Average deflection charts of seven geophones for Direction: Qom- Kashan, Section: 2 and Direction: Kashan- Qom, Section: 5.

The most deflection changes of each station shown in Fig. 8 indicate that the pavement has the unsuitable condition and more damaged. Thus, overlay design seems to be essential for two directions. The average deflection between station 44 km and station 47 km, for Direction: Qom- Kashan, Section: 2 (that trailers are without load most of the time in this direction) is equal to 142.25 microns. While, the average deflection between station 44 km and station 47 km, for Direction: Kashan-Qom, Section: 5 (that trailers are loaded in Bandar Abbas most of the times in this direction) is equal to 151.82 microns.

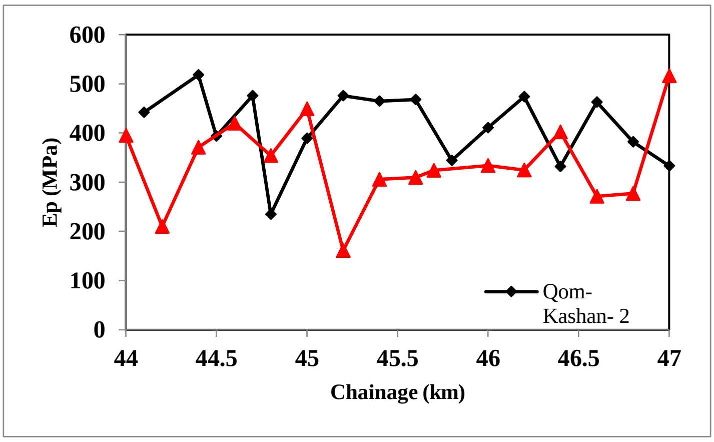

Fig. 9. Effective modulus of all pavement layers up to the bed for Direction: Qom- Kashan, Section: 2 and Direction: Kashan- Qom, Section: 5.

As presented in Fig. 9, if the effective modulus of all pavement layers (E_p) in each station be more, the pavement has more strength of layers in different traffic conditions. The average effective modulus of all pavement layers up to the bed between station 44 km and station 47 km, for Direction: Qom- Kashan, Section: 2 (that trailers are without load most of the time in this direction) is equal to 412.62 MPa. While, the average effective modulus of all pavement layers up to the bed between station 44 km and station 47 km, for Direction: Kashan-Qom, Section: 5 (that trailers are loaded in Bandar Abbas most of the times in this direction) is equal to 339.06 MPa.

The calculated overlay thickness diagrams for two directions in each station are indicated in Fig. 10.

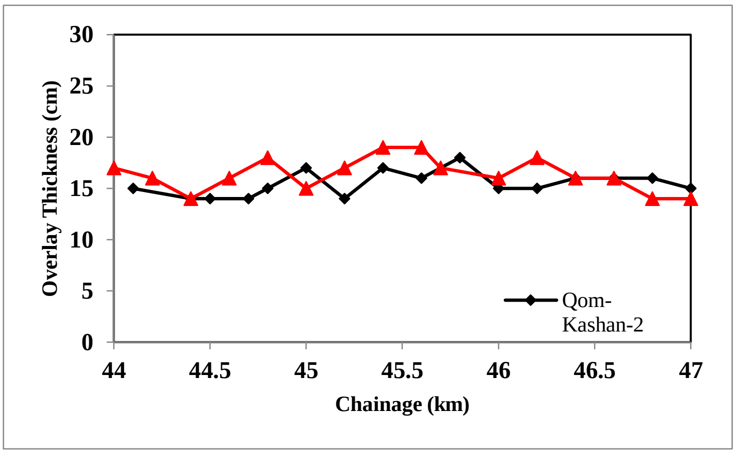

Fig. 10. Calculated overlay thickness diagram for Direction: Qom- Kashan, Section: 2 and Direction: Kashan-Qom, Section: 5.

As shown in Fig. 10, each station that has more deflection (Fig. 9) and less modulus (Fig. 10) needs more-overlay thickness to pavement rehabilitation and improvement process.

The average calculated overlay thickness between station 44 km and station 47 km, for Direction: Qom-Kashan, Section: 2 (that trailers are without load most of the time in this direction) is equal to 15.44 cm. While, the average calculated overlay thickness between station 44 km and station 47 km, for Direction: Kashan-Qom, Section: 5 (that trailers are loaded in Bandar Abbas most of the times in this direction) is equal to 16.38 cm. As indicated in Fig. 11 and Fig. 12, the sound or green color is associated with SCI above 1, warning or amber color is associated with SCI between 1 and 0.75, and the severe or red condition is associated with SCI values below 0.75. Fig. 11 presents SCI diagram for Direction: Qom- Kashan, Section: 2, before and after applying the overlay thickness on the existing asphalt pavement.

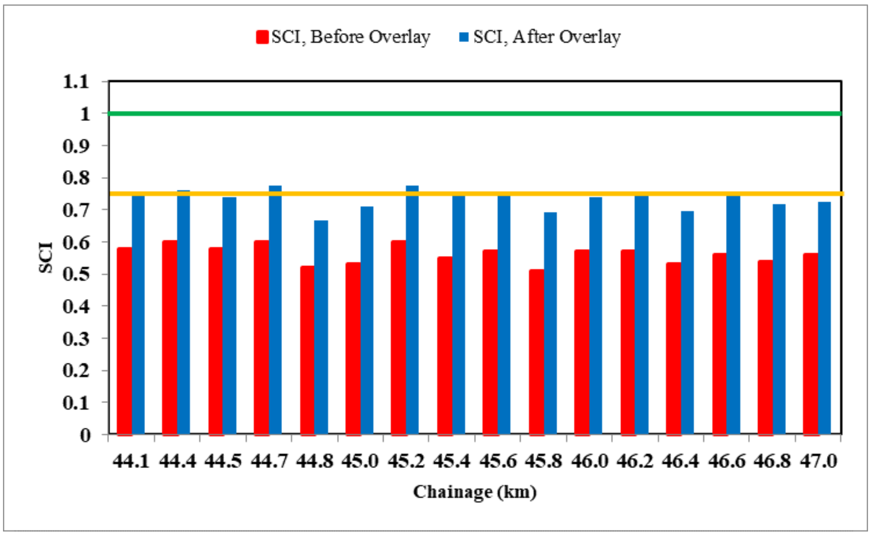

Fig. 11. SCI diagram for Direction: Qom- Kashan, Section: 2.

The *SCI* results indicate that before applying overlay for Direction: Qom- Kashan, Section: 2 in Fig. 11, the existing asphalt pavement is in severe condition. However, using the overlay improves the most stations of the existing asphalt pavement to warning condition. While arrive to having the sound condition for the pavement in this direction, needs to increase more the overlay or using another method to the pavement rehabilitation.

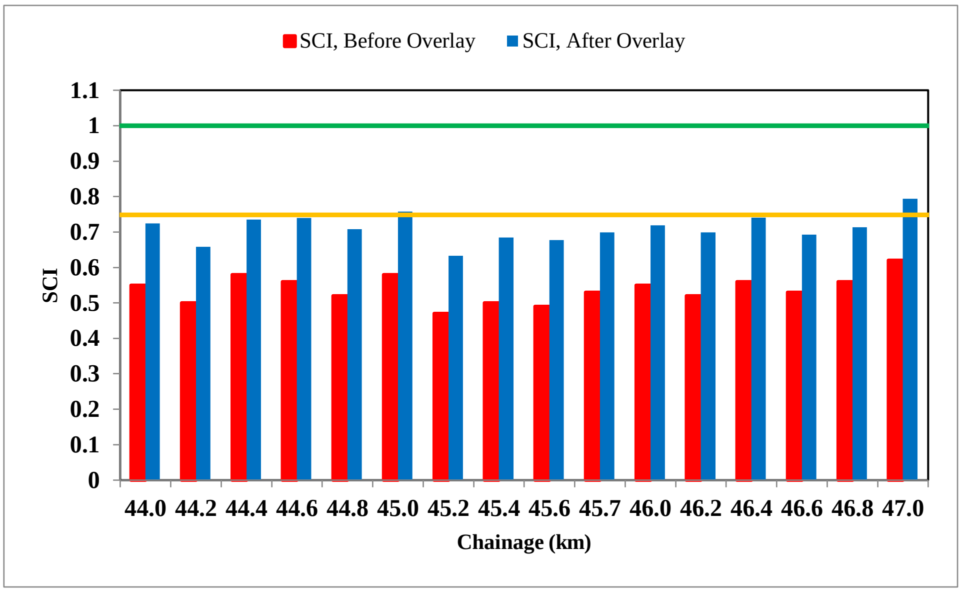

Fig. 12. *SCI* diagram for Direction: Kashan- Qom, Section: 5.

As indicated in Fig. 12 for Direction: Kashan-Qom, Section: 5, before applying overlay, *SCI* for all stations was in the severe or red condition falling below the amber line. However, using the overlay improves some stations of the existing asphalt pavement to warning condition. While, the average calculated overlay thickness between station 44 km and station 47 km, for Direction: Kashan-Qom, Section: 5 (that trailers are loaded in Bandar Abbas most of the times in this direction) is more than Direction: Qom- Kashan.

Moreover, the average *SCI* between station 44 km and station 47 km, for Direction: Qom- Kashan, Section: 2, shown in Fig. 10, (that trailers are without load most of the time in this direction) is equal to 0.733. Also, the average *SCI* between station 44 km and station 47 km, for Direction: Kashan-Qom, Section: 5, shown in Fig. 13, (that trailers are loaded in Bandar Abbas most of the times in this direction) is equal to 0.711. These results indicate that loading heavy vehicles in Bandar Abbas and returning to Direction: Kashan-Qom has caused more damage in this direction. Fig. 13 indicates further damage of Direction: Kashan-Qom.

(a)

(b)

Fig. 13. Damage image for Direction: (a) Qom- Kashan, Section: 2; (b) Kashan- Qom, Section: 5.

4. Conclusion

The FWD device is one of the non-destructive devices that provides inexpensive tests and fast to obtain graphical results of pavement design used in the evaluation of road pavement structures. In this research, the details of the FWD in the proposed sections of Amirkabir Freeway (Qom- Kashan Freeway) are investigated for two directions: Qom- Kashan (that trailers are without load most of the times in this direction) and Kashan- Qom (that trailers are loaded in Bandar Abbas most of the times in this direction). FWD data analysis that is as follows includes the pavement deflection and load chart at 900 kPa stress level for each station of each section, the average deflection chart of seven geophones for each station of each section, and the calculated overlay thickness diagram for each station of each section.

The results indicate that the average deflection between station 44 km and station 47 km, for Direction: Qom- Kashan, Section: 2 is equal to 142.25 microns. While, the average deflection between station 44 km and station 47 km, for Direction: Kashan-Qom, Section: 5 is equal to 151.82 microns. The reason for this result is the loading of heavy vehicles in Bandar Abbas city and travel in Direction: Kashan-Qom with heavy loads.

Furthermore, the average effective modulus of all pavement layers up to the bed between station 44 km and station 47 km, for Direction: Qom- Kashan, Section: 2 is equal to 412.62 MPa. While, the average effective modulus between station 44 km and station 47 km, for Direction: Kashan-Qom, Section: 5 is equal to 339.06 MPa.

So, as expected, Direction: Kashan-Qom has more deflection and less effective modulus than Direction: Qom- Kashan.

Based on objective observation of the surface of the pavement, Direction: Kashan-Qom needs more-overlay thickness than Direction: Qom- Kashan. So, the average calculated overlay thickness between station 44 km and station 47 km, for Direction: Qom- Kashan, and Direction: Kashan-Qom is equal to 15.44 cm, and 16.38 cm, respectively.

In this research, Structural Condition Index (*SCI*) as a screening tool is also calculated for decisions regarding maintenance and rehabilitation of pavements. The *SCI* results indicate that before applying overlay for two directions, the existing asphalt pavement is in severe condition. However, for Direction: Qom- Kashan, and Direction: Kashan-Qom, using the overlay improves the most stations and some stations of the existing asphalt pavement, respectively, to warning condition. While arrive to having the sound condition for the pavement in this direction, needs to increase more the overlay or using another method to the pavement rehabilitation.

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Conflicts of Interest

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

Authors' Contribution Statement

Atiye Farahani: Conceptualization; Formal analysis; Investigation; Methodology; Resources; Software; Supervision; Validation; Visualization; Roles/Writing – original draft; Writing – review & editing.

Hosein Zanjirani Farahani: Data curation; Investigation; Methodology; Project administration; Resources; Supervision; Writing – review & editing.

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