Appendix 10. Traffic

10.1. Falling Weight Deflectometer Testing Report

Structural Evaluation

Of

Local Road from R733 to Great Island

Falling Weight Deflectometer Testing

Level 1&2 Analysis

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Introduction

Falling Weight Deflectometer (FWD) testing was carried out on a Local Road Section from R733 to Great Island in Co. Wexford by Pavement Management Services on behalf of Mott MacDonald Ireland in October 2009. The section tested runs Westbound for 5000 metres. Testing was carried out in both carriageway lanes at 50 metre intervals, staggered in adjacent lanes.

Description of Deflection Testing Equipment

The equipment used to carry out the deflection survey was a Dynatest Model 8081 Falling Weight Deflectometer (FWD). The Falling Weight Deflectometer works on the same principle as all deflection devices; a load of known magnitude is imparted to the pavement, and the resulting deflections of the pavement are measured. For this project, interest centred on deflections under typical HCV wheel loads of 40 kN. There is a deflection-measuring sensor built into the centre of the load plate to measure the maximum deflection (D1), and a series of further sensors are also placed on the pavement surface to measure deflections at radial distances from the load application. In the testing done in Ireland, the standard 300mm spacing is used, with sensors (D2 to D7) at 300, 600, 900, 1200, 1500 and 1800 mm from the centre of the load plate.

FWD Test Results

Table 1 for the section shows the physical identifiers along each section length. Chainage referred to in all subsequent tables is in the direction shown in Table 1, i.e. Westbound. Appendix A shows the D1 deflection, Surface Curvature Index (SCI) and D7 deflection results at each point on each carriageway lane tested. In all cases, the lowest D1 results are the best from a structural viewpoint. The SCI (D1-D2) results indicate the condition of the upper pavement layers. Low SCIs (less than 250 microns) indicate good quality upper pavement layers. The D7 deflections are a good indicator of the subgrade. As with the D1 deflections, the lower the D7 deflections, the better the subgrade support.

Tables 2a to 2c for the section compares the overall carriageway results to typical results on similar roads. **Figures 1 to 3** show the D1, SCI and D7 results along the section length.

Based on the deflection results, the pavement lanes are divided into homogeneous segments on the basis of deflection. **Table 3** shows these homogeneous segments ranked based on average deflection.

The D1 deflections are very high throughout the section, generally indicating poor or very poor overall pavement conditions with failure occurring in many locations particularly on the Eastbound Carriageway.

SCI values are significantly high with values in excess of 250 microns throughout most of the section indicating very poor load spreading ability of the upper pavement layers.

The D7 deflections are generally low indicating very good subgrade conditions for the most part. The D7s are very high however from Chainage 2250 to 2800 indicating the presence of peat or some other highly compressible subgrade material along this stretch.

Pavement Construction

Pavement Coring & DCP Testing was carried out by PMS Pavement Management Services Ltd. to determine the as-constructed thicknesses of the existing pavement layers. Results from the coring investigation showed that the existing surface layer consists of a thin bituminous layer or surface dressing varying between 25 and 90 mm thick, but generally less than 50 mm. This layer is of insufficient thickness to treated as a distinct structural layer, providing additional strength, in the pavement analysis. Analysis of the DCP data shows that a relatively thin granular layer (generally 100 to 200 mm) lies underneath the surface layer at most locations.

Backcalculation of Layer Moduli

Using FWD testing, a 40kN load can be applied to the pavement, and the actual deflections at given distances from the centre of the load plate are measured. We now have pavement thicknesses, and displacements resulting from application of a 40 kN load. It is then possible to deduce what the elastic moduli of the pavement layers must be in order to have produced the deflection basin measured by the FWD device. This process is known as BACKCALCULATION of pavement layer moduli.

In practice, it is not easy to backcalculate layer moduli. A set of moduli is assumed, and the resulting deflections are calculated. These resulting deflections are compared to the actual measured deflections, and adjustments made to the original assumed moduli. These adjusted moduli are then used with the analytical software, and a new set of resulting deflections are calculated and compared with the actual measured deflections. The iterative process continues until the actual deflections and calculated deflections are sufficiently close, and the pavement is then characterised by this last set of pavement moduli.

Having characterised the pavement, the analysis can then proceed as in the case of a new pavement, with stresses and strains at the critical design locations being calculated, and number of axles to failure being calculated. If the number of axles to failure for the existing pavement is less than that desired (i.e. if the strains are excessively high), then an overlay layer can be designed to reduce the critical strains to the appropriate design level.

Application of Analytical Design Methods

With the existing pavement structure defined in terms of thicknesses, and a set of deflections available from the FWD testing, it was possible to use a backcalculation procedure as described in the previous section to obtain the pavement layer moduli from multilayer elastic analysis. For the purposes of backcalculation an effective upper granular layer thickness of 200 mm was assumed for the section.

Based on the deflection results, the pavement lanes were divided into homogeneous segments and design deflections were calculated based on the 85th percentile in each class. A pavement overlay design is then performed using the existing pavement structure at the design locations for each segment, and variable thicknesses of hot-mix or wet-mix overlay.

Traffic Requirements

Table 4 shows the design traffic and the cumulative number of standard axles over a 20 year design period. This was calculated using the existing traffic projected over a 20 year period using an annual growth rate of 3.5% and the traffic generated by proposed developments at the site.

Information received from Mott MacDonald Ireland indicates that the current AADT and HGV content are estimated as 831 and 3.4%, respectively. During construction phase, the development will generate a peak of 400 car trips and 20 HGV trips to and from the site each day. This peak construction traffic will occur during the year 2012. During the operational phase, it is expected that additional an 30 cars and six HGVs will be generated by the development.

As the existing road width is narrow, HGV traffic generally tend to use the full width when travelling along the length of the section tested. Therefore, it has been assumed that all HGV traffic will straddle both carriageways and this has been taken into account when calculating the cumulative design traffic shown in Table 4.

Structural Requirements

DEHLG guidelines specify that where SCIs are greater than 250 microns, a hot-mix only overlay is not suitable. Taking into account the design traffic requirement and the fact that the SCIs along the length of each carriageway are generally well in excess of 250 microns, a Clause 804/wet-mix macadam overlay was deemed to be more appropriate than an hot-mix overlay. **Table 5** shows the Clause 804/Wet-mix

macadam overlay requirements by segment for the section based on Non-National Road models (50th% failure curve).

A minimum thickness of 150 mm of wet-mix macadam is specified in the DEHLG guidelines for strengthening of Non-National roads. The wet-mix/Clause 804 overlay layer should be double surface dressed to seal the unbound material. The thicknesses shown may be superseded by construction requirements.

It should be noted that the overlay requirements shown in Table 5 are estimated using the traffic data provided by the client and shown in Table 4. If significantly higher HGV traffic volumes than those shown are anticipated, an overlay consisting hot-mix surface layer over a wet-mix/Clause 804 layer would be more appropriate.

Local Road from R733 to Great Island

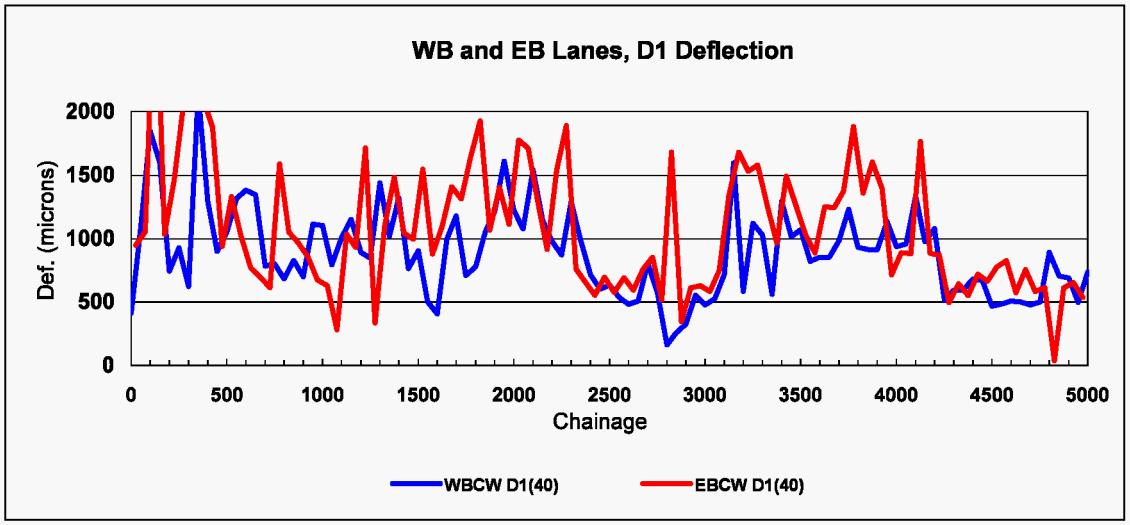

Figure 1: D1 Deflection Plots

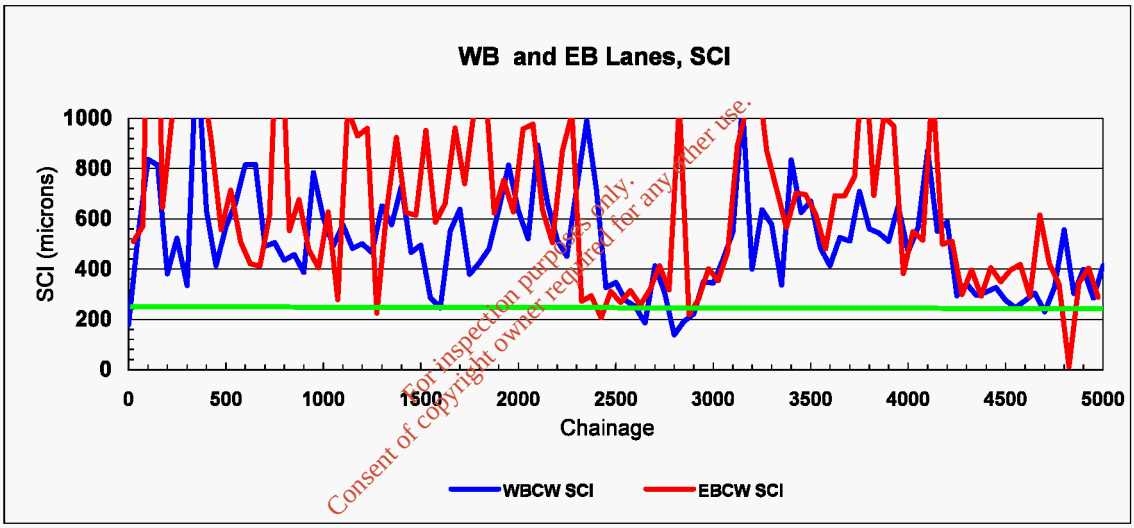

Figure 2: SCI Plots

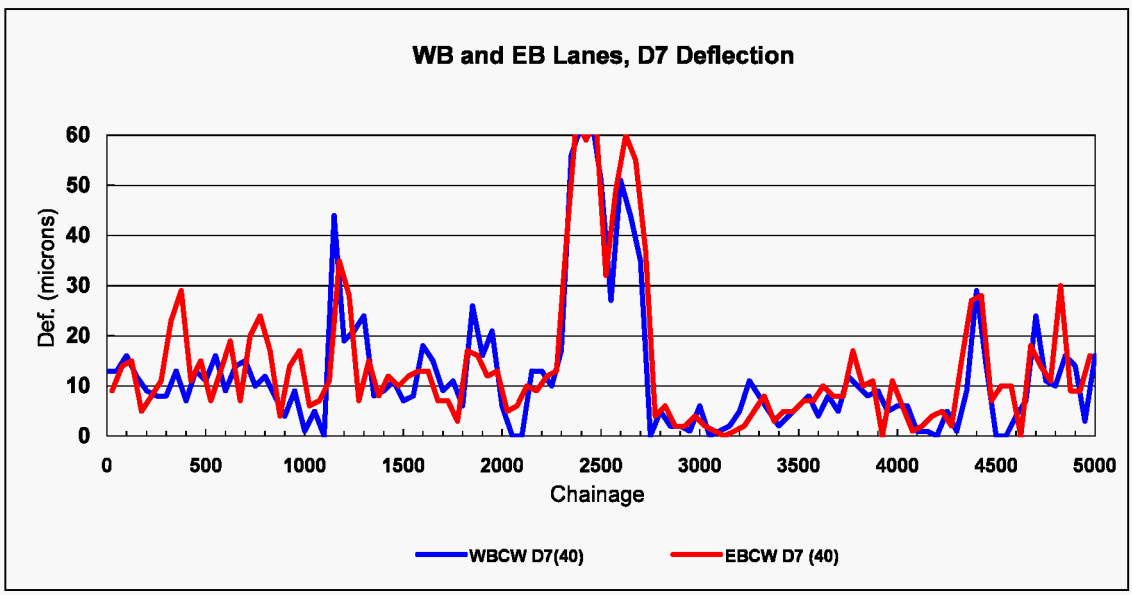

Figure 3: D7 Deflection Plots

CHAINAGE (metres)	Physical Identifier Westbound Direction
0	Started at horizontal white line at Junction with R733
400	17m West of centre white line of entrance to Cherry Grove on RHS
900	20m East of entrance to white bungalow with tiled roof on RHS
1100	13m West of centre of Junction LHS
1400	10m West of centre of Junction LHS
2000	32m West of centre of Junction RHS
3050	Opposite centre of Junction RHS on sharp bend Left
3750	16m East of centre of Junction LHS
4450	7m West of entrance to small bungalow tiled roof green gates on RHS
4800	20m West of centre of rail bridge
5000	Finished 8m East of gate to ESB

Table 1: Physical Locations by Chainage

Local Road from R733 to Great Island Average Deflections	County Road D1 Deflection Criterion
	< 450 microns - Very Good 450 to 600 microns - Good 600 to 800 microns - Fair
WBCW = 890 microns	**800 to 1000 microns - Poor**
EBCW = 1079 microns	**1000 to 1300 microns - Very Poor**
	> 1300 microns - Failed

Table 2A: Classification of Section Based on Overall Average D1

Local Road from R733 to Great Island Average SCIs	Surface Curvature Index (SCI) Indicating Condition of Upper Layers
	< 150 microns - Very Good 150 to 250 microns - Good 250 to 400 microns - Poor
WBCW = 506 mic., EBCW = 654 mic.	**> 400 microns - Very Poor**

Table 2B: Classification of Section Based on Overall Average SCI

Local Road from R733 to Great Island Average D7 Deflection	D7 Deflection Criterion Indicating Condition of Subgrade
	< 5 microns - Rock/Substantial Depths of Fill
WBCW = 12 mic., EBCW = 14 mic.	**5 to 15 microns - Very Good**
	15 to 20 microns - Good 20 to 30 microns - Fair 30 to 40 microns - Poor 40 to 50 microns - Very Poor > 50 microns - Peat

Table 2C: Classification of Section Based on Overall Average D7

Lane	Chainage	Description	Average D1 (microns)	Average SCI (microns)	Average D7 (microns)
WBCW	0 to 700	Very Poor	1191	629	12
WBCW	700 to 950	Fair	759	455	10
WBCW	950 to 1450	Very Poor	1068	587	14
WBCW	1450 to 1850	Fair	780	436	11
WBCW	1850 to 2400	Very Poor	1180	664	16
WBCW	2400 to 3150	Good	525	337	23
WBCW	3150 to 4250	Very Poor	1008	595	6
WBCW	4250 to 5000	Good	595	324	10
EBCW	0 to 625	Failed	1604	977	13
EBCW	625 to 1125	Poor	812	606	14
EBCW	1125 to 2325	Very Poor	1298	794	12
EBCW	2325 to 3125	Fair	703	360	30
EBCW	3125 to 4175	Failed	1303	785	6
EBCW	4175 to 5000	Fair	635	370	13

Table 3: Ranking Based on Average D1 of Design Segments

	Design Period	AADT	% Heavy Goods Vehicles	Standard Axles per Vehicle	Cumulative no. of Standard Axles
Existing Traffic	20 years	831	3.4	1	300,000
Construction Traffic	1 year	420	4.8	9	70,000
Operational Traffic	20 years	36	16.7	3	130,000
Total Design Traffic					500,000

Table 4: Traffic Design Parameters

		Non-national Models
Lane	Chainage	Overlay Requirements (Wet-mix/Cl. 804)
WBCW	0 to 700	200 mm
WBCW	700 to 950	150 mm
WBCW	950 to 1450	175 mm
WBCW	1450 to 1850	150 mm
WBCW	1850 to 2400	200 mm
WBCW	2400 to 3150	150 mm
WBCW	3150 to 4250	150 mm
WBCW	4250 to 5000	150 mm
EBCW	0 to 625	200 mm
EBCW	625 to 1125	150 mm
EBCW	1125 to 2325	175 mm
EBCW	2325 to 3125	150 mm
EBCW	3125 to 4175	200 mm
EBCW	4175 to 5000	150 mm

Table 5: Wet-mix or Clause 804 Overlay Requirements by Segment

APPENDIX A

D1, SCI and D7 Results

Local Road from R733 to Great Island			
Westbound Carriageway			
Chainage (metres)	D1(40) (microns)	SCI (microns)	D7 (microns)
0	413	177	13
50	1092	535	13
100	1849	837	16
150	1600	813	12
200	740	382	9
250	926	523	8
300	622	334	8
350	2150	1290	13
400	1294	635	7
450	899	414	13
500	1048	569	11
550	1317	663	16
600	1382	815	9
650	1346	817	14
700	783	491	15
750	803	506	10
800	681	435	12
850	827	458	8
900	699	387	4
950	1115	784	9
1000	1102	604	1
1050	792	492	5
1100	1004	576	0
1150	1151	482	44
1200	890	502	19
1250	846	466	21
1300	1438	652	24
1350	1021	576	8
1400	1320	731	9
1450	763	467	11
1500	904	494	7
1550	502	286	8
1600	407	245	18
1650	995	553	15
1700	1178	638	9
1750	710	379	11
1800	779	425	6
1850	1053	481	26
1900	1210	636	16
1950	1609	814	21
2000	1224	630	6
2050	1076	520	0
2100	1540	893	0
2150	1144	660	13
2200	979	515	13
2250	870	451	10
2300	1289	717	17
2350	991	990	56
2400	717	717	62
2450	601	327	64
2500	633	347	51

Local Road from R733 to Great Island			
Westbound Carriageway			
Chainage (metres)	D1(40) (microns)	SCI (microns)	D7 (microns)
2550	538	276	27
2600	484	251	51
2650	508	186	44
2700	800	414	35
2750	577	306	0
2800	163	139	5
2850	257	192	2
2900	326	222	2
2950	553	349	1
3000	476	344	6
3050	524	438	0
3100	716	548	1
3150	1594	1055	2
3200	583	399	5
3250	1121	637	11
3300	1028	577	8
3350	559	337	5
3400	1293	835	2
3450	1014	625	4
3500	1069	671	6
3550	819	485	8
3600	854	414	4
3650	854	525	8
3700	985	512	5
3750	1232	709	12
3800	933	560	10
3850	912	544	8
3900	911	510	9
3950	1133	652	5
4000	937	468	6
4050	956	566	6
4100	1334	873	1
4150	975	552	1
4200	1078	588	0
4250	514	294	5
4300	594	342	1
4350	596	295	9
4400	681	309	29
4450	673	327	14
4500	467	276	0
4550	487	247	0
4600	507	275	4
4650	501	305	7
4700	475	231	24
4750	501	328	11
4800	892	557	10
4850	705	302	16
4900	689	398	14
4950	497	285	3
5000	734	414	16

Local Road from R733 to Great Island			
Eastbound Carriageway			
Chainage (metres)	D1(40) (microns)	SCI (microns)	D7 (microns)
25	948	511	9
75	1055	571	14
125	3291	2502	15
175	1035	645	5
225	1457	1019	8
275	2074	1282	11
325	2120	1320	23
375	2110	1182	29
425	1874	913	11
475	941	558	15
525	1331	714	7
575	1017	508	13
625	769	421	19
675	698	413	7
725	614	614	20
775	1588	1587	24
825	1050	554	17
875	965	678	4
925	855	478	14
975	675	405	17
1025	627	627	6
1075	279	279	7
1125	1035	1034	11
1175	930	929	35
1225	1713	960	28
1275	334	226	7
1325	1100	639	15
1375	1483	924	8
1425	1046	625	12
1475	995	615	10
1525	1545	952	12
1575	879	587	13
1625	1092	661	13
1675	1408	962	7
1725	1312	740	7
1775	1640	1034	3
1825	1929	1203	17
1875	1066	623	16
1925	1404	754	12
1975	1115	627	13
2025	1777	958	5
2075	1710	977	6
2125	1301	636	10
2175	913	506	9
2225	1541	870	12
2275	1889	1020	13
2325	760	273	39
2375	652	294	63
2425	553	207	59
2475	696	311	63
2525	576	267	32

Local Road from R733 to Great Island Eastbound Carriageway			
Chainage (metres)	D1(40) (microns)	SCI (microns)	D7 (microns)
2575	691	316	49
2625	593	257	60
2675	758	319	55
2725	854	414	37
2775	516	319	4
2825	1680	1060	6
2875	347	218	2
2925	611	281	2
2975	628	401	4
3025	584	353	2
3075	746	471	1
3125	1334	891	0
3175	1681	1055	1
3225	1529	1186	2
3275	1581	869	5
3325	1260	720	8
3375	964	565	3
3425	1493	702	5
3475	1257	697	5
3525	1027	616	7
3575	887	481	7
3625	1248	693	10
3675	1244	693	8
3725	1373	768	8
3775	1882	1302	17
3825	1358	694	10
3875	1602	1009	11
3925	1397	969	0
3975	715	383	11
4025	888	550	6
4075	882	516	1
4125	1765	1132	2
4175	884	500	4
4225	869	512	5
4275	495	299	2
4325	642	397	15
4375	550	292	27
4425	719	407	28
4475	664	350	7
4525	775	397	10
4575	825	419	10
4625	575	291	0
4675	755	615	18
4725	585	421	14
4775	614	340	11
4825	40	13	30
4875	610	344	9
4925	653	404	9
4975	536	288	16