FIELD MEASUREMENT FOR AXLE LOADS OF VEHICLES

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1. INTRODUCTION Estimation of traffic loading and its modelling are important for evaluation of structural safety of highway bridges. For the design of slabs and floor system, wheel loads properties are also required. However, information about the wheel loads are not enough yet. The authors are strongly interested to develope appropriate design wheel loads through measureing the actual traffic loads. Structural behabiors of slabs subjected directly to the wheels are focussed as the most favorable characteristic to measure the wheel loads.

2. SLAB BEHAVIORS UNDER WHEEL LOADS Fig.1 represents a slab model subjected to tandem axle loads of 1.3m wheel base. Fig.2 shows the slab behaviors relating to the time evaluated by the plate theory. From those results, it can be concluded that the detailed responses of bending moment in the Y direction are clearly coincide with each wheel. Therefore, opening of crack in the direction perpendicular to the bridge axis seems to be a more favorable detector instead of moment, since the crack opening is integration for the bending strains between crack spacing.

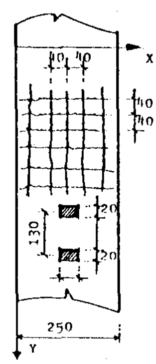

Fig.1 Slab model

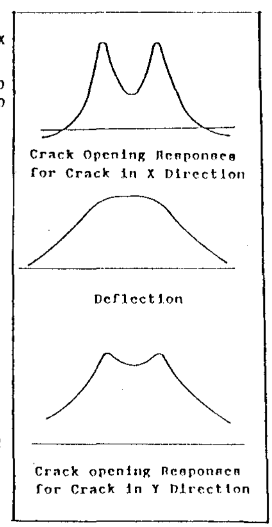

Fig.2 Slab behaviors relating to the time

This idea was carried out by a field measurement. The target bridge was a composite bridge in the Osaka City. Pai-shape strain gages were used to measure the crack opening as shown in Fig.3. The measurements were carried out for 24 hours.

3. OUTLINE OF OBTAINED RESULTS Fig.4 is an osillograph record about crack opening by the test truck of 3 axles. It is clear from the figure that the osillation numbers are corresponding to the axle numbers and rear axle responses can easily distinguished. These responses are more clear at the gages under the running position of wheels. However, the ratios of the front axle response to the rear axle responses at every gages are differed. So, a problem arised that which response can be used to estimate the wheel loads? Also, for reading the peak response height, where the datum line should be considered?

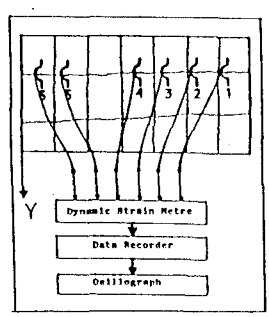

Fig.3 Data collection by Pai-gages

4. EVALUATION OF MEASUREMENT RESULTS To confirm the problems, the responses due to the test truck have been analized by the FEM. Fig.5 represents the analytical result which shows a good agreement to the surveyed one shown in Fig.4. By trial and error, it was found that the exact pulse height can be measured for a single axle from the line connecting both bottoms sandwiching the peak, and for tandem axle from the line connecting both outer bottoms of the successive double pulses. Eq.(1) related the pulse height to the weight and passing position has been derived considering the influence line of response for each gages.

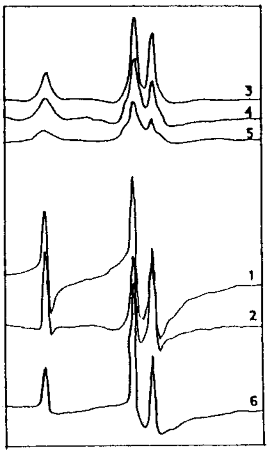

Fig.4 Measured crack opening responses by test truck

$$Y_i = K_i \cdot W \cdot (a_1X^5 + a_2X^4 + a_3X^3 + a_4X^2 + a_5X + a_6) \qquad (1)$$

where, Y_i : pulse height,

K_i : coefficient depending on the wheel track,

W : wheel weight or axle weight,

X : passing position measured form the center lane mark.

The parameters a_1 to a_6 can be determined from th influence line. Since it is very hard to solve Eq.(1) manually for every responses, a computer have to be used. The expecting values of the passing position and wheel loads will be the corresponding values to the minimum sum of squear difference given by

$$\Sigma(Y_{ni} - Y_{ei})^2,$$

where, i=1~6,

Y_{ni} :measured response by each gage,

Y_{ei} :assumed value calculated form Eq.(1).

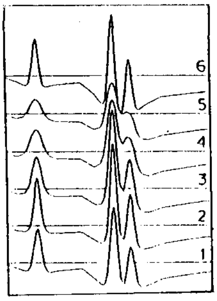

Fig.5 Crack opening responses of test truck by FEM

In computing the minimum value, W was varied from 0.1 to 20 ton by 0.1 ton increment, while X was varied from 0 to 120 cm by 1 cm increment.

Table 1 Estimated Wheel Loads for The Test Truck

Axle	Course 1		Course 2		Course 3		Scaled
	X	W	X	W	X	W	weight
Front	o	2.3	45	2.3	75	2.3	2.315
Tandem-Front	7	4.7	52	4.7	82	4.7	total
-Rear	8	3.0	59	3.1	86	3.0	7.765

X:Passing position in cm, W:Wheel weight in ton

Table 1 shows the estimated values for test truck by this developed method with those by weighing scale. From the coincide of the both values, reliability of the proposed method can be verified. Table 2 is a summary for the evaluation of 15 typical heavy vehicles. All the estimated values seem to be reliable since the differences in passing positions for the front and rear axles are about 10 to 12 cm which almostly fit to the designed values of trucks regulated by the authorities.

Table 2 Samples Estimated for Heavy Trucks

Trucks	No.	1st axle		2nd axle		3rd axle		4th axle		5th axle	
		X	W	X	W	X	W	X	W	X	W
2-Axle	1	66	1.5			82	3.4				
trucks	2	58	1.5			72	4.6				
	3	48	2.7			69	7.2				
3-Axle	4	72	3.0	75	5.0	81	4.1				
trucks	5	75	2.6	76	5.3	82	3.9				
	6	58	2.2	59	2.0	70	2.2				
	7	82	2.9	85	7.1	78	5.8				
	8	60	1.8			68	2.6	67	1.3		
	9	48	2.7			62	4.6	62	4.0		
	10	62	1.7			73	3.3	69	1.4		
	11	57	3.0			.71	6.5	72	4.3		
Trailer	12	46	2.0	46	3.1	58	5.3	61	4.1		
trucks	13	52	3.2			62	5.8	65	6.8	64	5.6
	14	55.	2.9	65	2.6	75	3.1	80	4.7	78	5.0
	15	61	2.4	61	2.9	69	5.4	65	3.6	68	4.4

The field measurements were carried out with the members of Fatigue Committee (Chairman : Prof. NAKAI of Osaka City University) of the Kansai Douro Kennkyuukai.