I-282 MEASUREMENTS OF AXLE WEIGHTS ON ROUTE 161 BY CRACK OPENINGS

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1. INTRODUCTION In the recent revised design codes for structures such as AASHTO, BS5400 and ONTARIO HIGHWAY CODE etc., the limit state design method has become popular for the design of highway bridges. However, allowable stress design method is still now applied in Japan. Until now the informations on load effects are not so enough to establish a reasonable design loads. The authors have been developed a new method for the estimation of vehicle axle weights of vehicles running at highway speeds(1) because those weights are required for the design of secondary bridge elements such as slabs and stringers. The method depends on measuring of crack openings due to an axle load at a crack occurring perpendicular to the running direction of vehicles on a bottom surface of RC slab. The main advantage of this method is that the method can be used for the estimation of axle weights of close axle combination like tandem-axles independently. In order to develop appropriate design wheel loads a measurement of axle weights by using this method were carried out on Hiragawa Bridge on Route 161. This paper describes the method of measurements, analysis technique and obtained results.

2. METHOD OF MEASUREMENTS The bridge is a non-composite through girder as shown in Fig.1. Since the bridge is tow-way and to measure the axle weights in the both direction of traffic, two cracks on the bottom surface of RC slab were selected and at each one three gages were connected. The gages were located so that the wheels of common trucks passed over them. The data collection technique is shown in Fig.2. The measurements were carried out for 24 hours. To get the relation between crack opening and axle weights and vehicle passing position, calibration running of test truck weighted before by truck scale were carried out by changing passing courses into 12 kinds (six for each traffic direction) in the lane width.

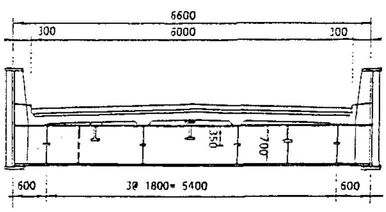

図1 測定橋梁横断面図

3. METHOD OF ANALYSIS With the obtained shape of responses shown in Fig.3-8, reading method of hump heights due to only plate action from total response can be assessed. From those figures it can be easily noticed that the responses never goes down into the negative zone. This phenomena means that the slab is located at or near to the location of the neutral axis of the girders. Therefore, the effect of beam actions seem to be not significant. The dotted line connecting a,b,d,e,g,i, and j shown in Fig.3 represents the tensile strain on the bottom surface of RC slab due to bending of whole bridge. This dotted line can be used as the datum lines to read the hump heights only due to the plate action.

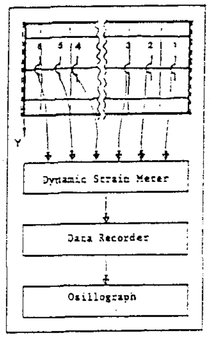

図2 データの収集方法

The crack opening responses are expressed as a function of the axle load W and passing position of vehicle X as shown by Eq.1.

$$Y_n = K_n W g_n(X) \quad \quad (1)$$

where, K_n = coefficient to be modified by setting levels of the strain amplifier and the data recorder,

$g_n(X)$ = influence value of influence line of passing position

The modified influence line $K_n g_n(X)$ for each gage can be expressed by a polynomial equation of 4th degree as shown in Eq.2.

$$K_n\, g_n(X) = a_{n1} + a_{n2}X + a_{n3}X^2 + a_{n4}X^3 + a_{n5}X^4 \qquad (2)$$

With a set of the three influence lines of each gage for each traffic direction and a set of responses from three gages, the weight of axle loads and the passing position can be estimated accurately by minimizing Eq.3.

$$\sum (Y_{mi} - Y_{ei})^2 \quad . \; . \; . \; . \; . \; . \; . \; . \qquad (3)$$

where, i = gage number

Y_{mi} = measured response height

Y_{ei} = estimated response height from influence lines equations

Table(1) shows the verification of the estimation of the axle weight for the test truck. The obtained results seem to be reliable since the difference in passing position for front and rear axles are about 10 to 20 cm. The error in estimation of the axle weights seem to be less than 10%.

表１　試験車に対する検証

計算により求めた各軸重（カッコ内誤差(%)）、走行位置（カッコ内誤差(cm)）

ケース	第１軸	第２軸	第３軸	総重量	コース(計算、観察)	
1	6.7(+ 9)	8.4(+ 4)	7.7(+16)	22.8(+ 9)	19(- 1)	20
2	5.9(- 3)	9.2(+17)	6.0(-10)	21.1(0)	40(0)	40
3	5.9(- 3)	9.2(+17)	6.6(0)	21.7(3)	52(- 8)	60
4	6.6(+ 7)	8.5(+ 5)	6.4(- 4)	21.5(+ 2)	77(+ 2)	75
5	5.9(- 3)	8.3(+ 2)	6.5(- 2)	20.7(- 1)	16(- 4)	20
6	6.6(+ 7)	8.6(+ 7)	6.3(- 5)	21.5(+ 2)	19(- 1)	20
7	6.2(+ 1)	8.4(+ 4)	6.4(- 4)	21.0(0)	45(+ 5)	40
8	6.6(+ 7)	9.0(+13)	6.0(-10)	21.6(+ 3)	71(- 4)	75
9	6.0(- 1)	8.1(0)	6.7(0)	20.8(- 1)	79(- 1)	80
10	6.2(+ 1)	8.6(+ 7)	6.2(- 6)	21.0(0)	53(+ 3)	50
11	6.1(0)	8.7(+ 8)	6.6(0)	21.4(+ 2)	19(- 1)	20
12	7.3(+19)	7.1(-17)	6.6(0)	21.0(0)	6(+ 1)	5
averag	6.3(+ 3)	8.5(+ 4)	6.8(+ 1)	21.3(+ 2)	(-0.75)	
Sx	0.43	0.56	0.87	0.56		

単位 : (ton)　　単位 : (cm)

4. TRUCK WEIGHT AND AXLE WEIGHT DISTRIBUTION

After the verification of the estimation method , the data of 24 hours were analyzed. Fig.9 and Fig.10 are the results about the distribution of total weight and axle weights respectively.

ACKNOWLEDGMENT: This research is supported by Grant-in-Aid for Scientific Research.

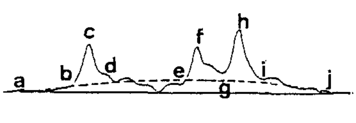

図３　試験車応答波形

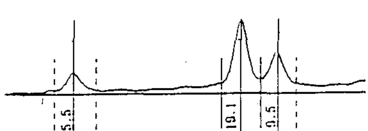

図４ 後タンデム３軸車 ΣW=34.1ton

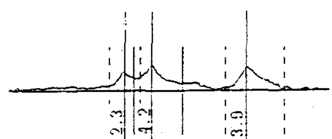

図５ 前タンデム３軸車 ΣW=10.4ton

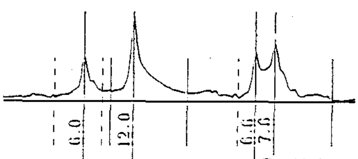

図６ セミトレーラー

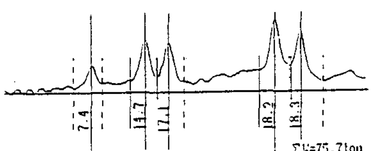

図７ トレーラー

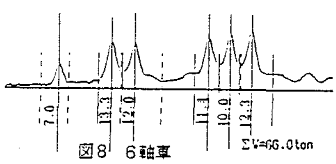

図８ ６軸車

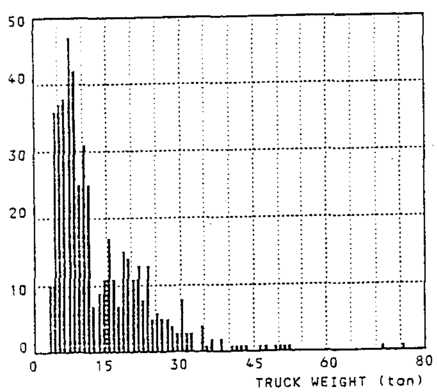

図９　全重分布

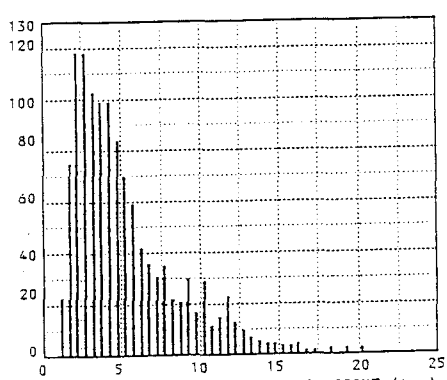

図１０　軸重分布

REFERENCE(1): S. Matsui and A. EL-HAKIM, "Estimation of Axle Weight of Vehicles by Crack Opening of RC Slab", Journal of Structural Engineering, JSCE, Vol.35A, 1989.