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EXPERIMENTAL STUDY ON THE CONSTRUCTION OF A HYBRID BRIDGE STRUCTURE BY UTILIZING SUSPENDED CONCRETE SLAB

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INTORDUCTION

In the recent years,the use of new construction methods for concrete structures have been given a considerable attention.In the present work,a suspended concrete slab bridge (or stress-ribbon bridge) is combined with diagonal steel elements and upper concrete slab to construct a simply supported hybrid bridge structure. Precast concrete segments connected together using mortar joints are used to erect suspended concrete slab bridge. These segments are hung on two bearing PC cables in a pair of troughs. After casting the upper slab, the specimen is prestressed by releasing the anchors of the bearing PC cables and also by a central PC cable placed in the middle duct of the segments. The characteristic behavior of the hybrid bridge under loading for various prestressing values of central PC cable is investigated. Furthermore, analytical results obtained using conventional linear analysis are compared with experiment measurements.

TEST PROGRAM AND MATERIAL PROPERTIES

A simply supported hybrid bridge specimen with clear span 5.00 m was tested. The details of the specimen are summarized in Fig. 1. Four cases were tested by varying the prestressing force in the central PC cable. In each case, the deflection and strains before and after releasing the anchors were obtained. Table 1 shows the prestressing values for each case. Properties of concrete, mortar, PC cables, and reinforcement are given in Table 2.

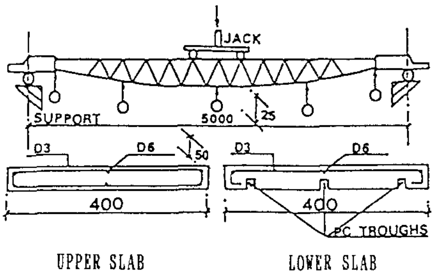

Fig. 1 Details of Specimen and Loading Arrangements.(All Dim. in mm).

Table 1 Prestressing Forces (tonf)

Case No.	East Cable	Central Cable	West cable
1	2.60	4.80	2.60
2	2.60	2.40	2.60
3	2.60	0.00	2.60
4	2.60	2.60	2.60

Table 2 Materials Properties (kgf/cm2)

a) Concrete and Mortar

Type	f_c	f_t	E_c	ν
Lower Slab	570	35	3.00E+05	0.182
Upper Slab	550	30	2.90E+05	0.187
Mortar	-	-	2.20E+05	0.210

b) Reinforcements and PC cables

Type	f_y	f_u	E_c or E_p	ε%
Reinf.	3400	4900	2.10E+06	29
PC cables	14250	14860	2.00E+06	11

All specimens are in accordance with JIS

INSTRUMENTATION AND TESTING

The typical loading arrangements for the specimen are shown in Fig. 1. The specimen was subjected to two equal vertical concentrated loads applied on the top of upper concrete slab at two positions apart by 600 mm on either side of mid-span. Load from 50 tonf hydraulic jack was applied in an increments of 0.25 tonf. The vertical deflections of the bridge were measured at various positions along the specimen as shown in Fig. 1. Strain gauges were placed on PC cables, diagonal bars and on the vertical faces of the concrete at various positions. The output from both strain and deflection gauges were fed into a multi-channeled, computer controlled data-logging system.

TEST RESULTS AND DISCUSSION

In general, the structural behavior of this hybrid bridge after releasing the anchors is similar to that of ordinary prestressed concrete bridge. Failure was characterized by yielding of tension PC cables and extensive cracking in the tension zone. Typical characteristics of the tested bridge response to loading are summarized as follows :

1. Cracking Load

The cracking loads for the different cases of tested specimen were between 1.0-1.25, 0.5-0.75, 0.0-0.25, and 0.75-1.0 tonf for cases number one, two, three, and four respectively. For case 4, cracking load was between 25 to 33 percent of the observed failure load. In all cases, the observed cracks were at lower slab except for cases 3 and 4, where hair cracks were observed in the bottom fiber of upper slab. Furthermore, all observed cracks in lower slab were due to debonding at mortar joints.

2. Deflection

The load versus maximum deflection curves for the various tested cases are shown in Fig. 2. In this figure the dotted line represents the calculated values obtained using linear method of structural analysis. In general, both measured and calculated values are approximately the same until the formation of the first crack. On the other hand, after first crack was observed, the load-deflection curves became noticeably nonlinear.

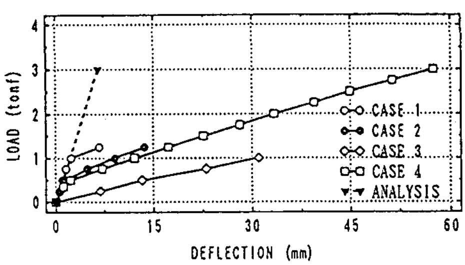

Fig. 2 Load-Deflection Curves.

3. Concrete Strains

A one sample of the load versus concrete strain curves at mid-span of lower slab as well as the corresponding calculated values is shown in Fig. 3. Generally, for lower concrete slab, the measured strain values are similar to the calculated values before the formation of first crack. After observation of first crack, concrete strain curves indicate a ductile behavior. Whereas for upper concrete slab, the difference between the measured and the calculated values is very small except for cases 3 and 4 where hair cracks were observed in the lower fiber around central part of the bridge. Furthermore, the change in concrete strains due to releasing the anchors of bearing cables and as a result the bridge is prestressed is shown in Fig. 4. Form detailed examination of Fig. 4 the following observations are noted :

a. For all different cases, the compressive strain due to self-weight of the specimen is added to the compressive strain due to transfer of prestressing force. Therefore, the compressive strain in upper slab is increased after releasing the bearing cables anchors. Moreover, the difference between the measured and the calculated values is minimal.
b. On the other hand, the tensile strain due to self-weight of the specimen is approximately equal to the compressive strain due to prestressing transfer. So that, the strain change of lower slab after lowering the bridge is small.

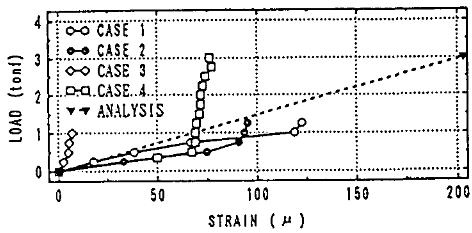

Fig. 3 Load-Strain Curves.

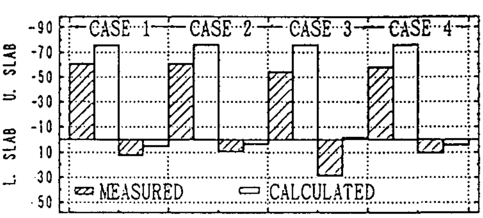

Fig. 4 Change in Concrete Strains.

CONCLUSIONS

1. A new practical method to construct a hybrid bridge is confirmed.
2. It was verified that the tension forces in the bearing PC cables were transformed to the bridge as prestressing force when the anchors of the bearing cables were released.
3. The structural behavior of this hybrid bridge is similar to that for an ordinary prestressed concrete bridge.

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