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Analysis of Fatigue Behavior of Steel-Concrete Composite Bridge Deck

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Summary

Due to the heavy vehicle traffic and environmental attacks, deterioration of the bridge decks is usually accelerated. Bridge deck often requires repairs and the deteriorated one should be rehabilitated or replaced. For these reasons, service life of the conventional bridge deck is several times shorter than those of other primary bridge components.

Therefore, this research wishes to examine behavior characteristic of steel-concrete composite bridge deck through fatigue test for the steel-concrete composite bridge deck that have higher stiffness than existent RC deck and fatigue design guide line including fatigue life characteristic.

Introduction

Bridge floor is directly exposed to external environment such as load from vehicles and weather, which means it is vulnerable to deterioration and damages, so its life is relatively shorter than other bridge materials. The existing bridge needs repairs and reinforcement to maintain and improve the load resistance and durability during the common use considering that the floor may be deteriorated. To minimize the maintenance of the bridge floor and guarantee the design life span of the whole bridge, it requires the development of new bridge floor of which strength and durability are superior to the existing ones.

As part of the research and development, to develop high strength and high durability floor, it is reasonably determined that the steel-concrete composite floor's behavior should be reviewed in order to appraise the performance such as economy and durability of the floor that can have high strength, restrict any crack and minimize the maintenance than the existing RC floor.

Therefore, the static load test and fatigue test for the steel-concrete composite floor were executed in the study to demonstrate the behavior characteristics of the floor. Also, based on the results of fatigue test, the fatigue design guide including the fatigue life of the steel-concrete composite floor would be proposed ultimately.

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Details of Steel-Concrete Composite Floor Specimen

Specifications of Specimen

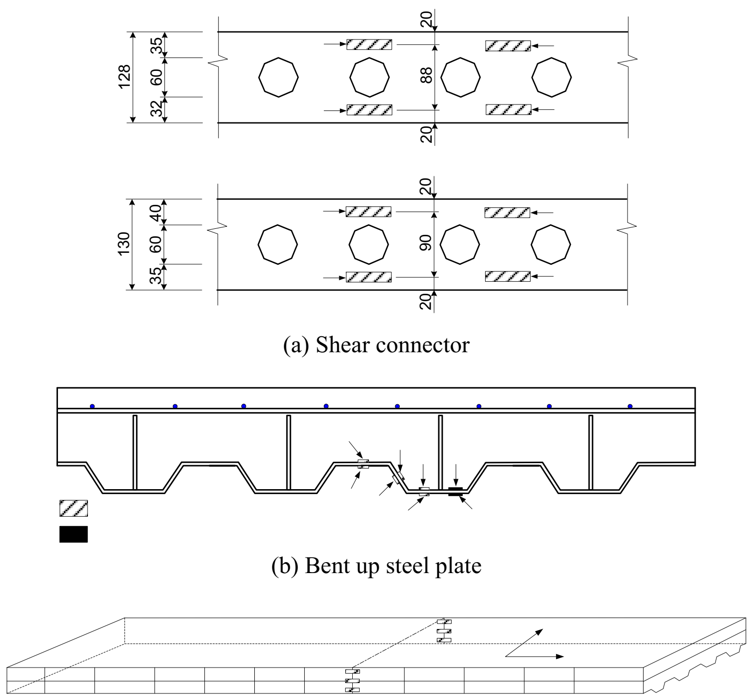
Table 1 summarizes the specifications of the fatigue Specimen of the steel-concrete composite floor. The bent up steel plate was manufactured of SS400, the steel material and concrete of which strength is f_{ck}=30MPa.

Table 1: Specification of Specimen

Specimen name	Dimensions(mm)
SF Specimen	3,700(L)*1,000(W)*220(H)*6(t)
PF Specimen	2,700(L)*1,000(W)*220(H)*8(t)

Measurement Points

Vertical displacement was measured at 1/2, 1/4 and 3/4 of the span to comprehend the entire behavior of the Specimen. Considering that the center of span may have the most displacement, when applying a load, due to the loading characteristics, plentiful strain gauges were attached on the center to check the steel behavior of the Specimen, as presented in Figure 1(a) and (b). In addition, strain gauges were attached, as presented in Figure 1(c) to evaluate the concrete behavior.



(a) Shear connector

(b) Bent up steel plate

(c) Concrete

Figure 1: Attachment positions of strain gauge

Fatigue test method

Fatigue test was executed with the load conditions as referred to Table 2, based on the crack-inducive load and ultimate load, which could be obtained in the static load test. The load range applying to each loading plate was between 100kN and 125kN, which was above the design axial load(96kN) of DB24 load described in the Design Specifications for Highway Bridges, so the fatigue life could be regarded as unlimited unless it showed fatigue crack unto 2 million repetitive times, at which the test ended. Here, the max load(Pmax) for SF3 and PF3 Specimens was almost 52% and 48% of the Specimens' ultimate load, respectively, which was intended to check whether it had any crack and where it might occur. In addition, the static load test was executed to comprehend any deteriorated material performance owing to fatigue load, after the 2 million times of loading test, unless it would not be destructed.

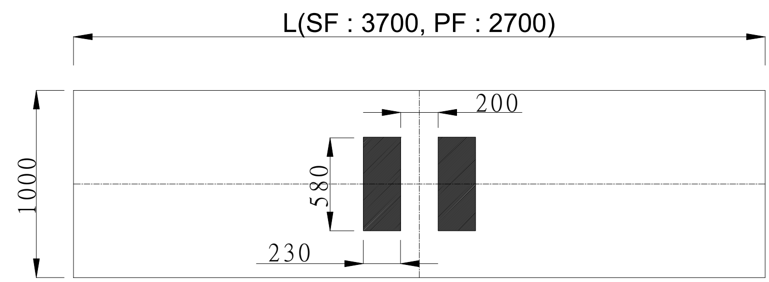


Figure 2: Position of load application

Table 2: Load condition of fatigue test(kN)

Specimen	SF-1	SF-2	SF-3	PF-1	PF-2	PF-3
Ultimate load		710			770	
Pmax	220	270	370	220	270	370
Pmin	20	20	20	20	20	20
Stress range	100 (basis)	125 (25%↑)	175 (75%↑)	100 (basis)	125 (25%↑)	175 (75%↑)

Fatigue Test Results of Steel-Concrete Composite Floor

Fatigue Test Results of SF Specimen

The behavior of the load-displacement curve up to 220kN of load in the fatigue test shows the results similar to the static (load) test, so the basic behavior of the fatigue test Specimen would be reasonably as same as the static load test Specimen.

Table 3 shows the max. stress, min. stress and stress range by the structures of SF Specimens.

The allowable fatigue stress range of the upper flange and middle part of the bent up steel plate was applied by Grade A, and the shear connector with closure

Table 3: Max./Min. Stress and Stress Range of SF Specimen(MPa)

Cate.	S2		S4		S6		S8		S10	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
SF1	109.8	7.8	80.2	5.4	62.4	5.2	91.4	9.4	136	17.2
(Stress range)	102		75		57		82		119	
SF2	320.6	4.6	91.6	1.8	81.6	2.2	118.4	3.6	152.2	4.6
(Stress range)	316		90		79		115		148	
SF3	78.2	.2	168	8.6	149.6	4.8	8.2	160	248.2	12
(Stress range)	77		159.4		144.8		151.8		236	

cross section and lower flange were applied by Grade B. However, since the shear connector with hole cross section does not have any fatigue criteria for the detailed structure in the domestic design specification, Grade C was applied by referring to JSSC Fatigue Design Criteria.

SF2 Specimen had the stress above the allowable fatigue stress range on the lower part of shear connector(S2) and the lower part of bent up steel plate(S10), which was probably due to locally concentrated stress resulting from welded joint and it is expected that the fatigue life would be unlimited because it did not have any fatigue crack in the 2 million repeat test. Unlike SF1, SF3 of which load is more 75% of SF1 had fatigue cracks on the shear connector of the center of bent up steel plate and the fillet welded joint of the lower flange, on which the crack was developed transversely and led to destruction at about 52 thousand times of the test. The fracture phase showed that the fatigue characteristics of the test Specimen would demonstrate single-load-path structure. Although SF3 Specimen was fractured owing to the crack on the lower flange, it also shows that it meets the lower flange grade(B) of bent up steel plate.

Fatigue Test Results of PF Specimen

PF Test Specimen's load-displacement curve up to 220kN of the fatigue test load as seen in Figure 3(b) shows the results similar to the behavior in the static load test.

Table 4 shows the max./min. stress and stress range by the detailed structures of PF test Specimens.

The fatigue grades were as same as SF Specimens. The lower part(S3) of the shear connector in PF3 had excessive stress beyond the allowable fatigue stress range, which might be probably due to the locally concentrated stress of welding work. PF3 Specimen had fatigue cracks on the center of bent up steel plate and was fractured at about 760 thousand times.

As the results of the fatigue tests for SF Specimen and PF Specimen, it was found that the life span of them would be almost unlimited when the upper flange

Table 4: Max./Min. stress and Stress range of PF Specimen(MPa)

Cate	S2		S4		S6		S8		S10	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
PF1	75.2	6.2	24.4	4.4	41.8	3.4	64.2	5.6	93.2	8.6
(Stress range)	69		20		38		59		85	
PF2	108	-5	27.8	-3.2	60.8	3.6	91.6	6.8	125.4	10.2
(Stress range)	113		31		57		85		115	
PF3	504.4	14.7	42.2	4.8	85.1	3.6	112	5	193.4	8.2
(Stress range)	489.7		37.4		81.5		107		185.2	

of bent up steel plate and the middle part of bent up steel plate were Grade A, and the shear connector and lower flange were Grade B. Therefore, it can be determined that when designing the fatigue of the steel-concrete composite floor, it would not make any problem if Grade A and Grade B are considered, respectively.

Conclusion

The fatigue test results of steel-concrete composite floor can be concluded as follows.

(1) Considering that the stress is locally concentrated on the welded joint of the bent up steel plate and shear connector, the further fatigue test should review the joint.

(2) By reviewing the fatigue design specification of countries and the previous research results, the study suggests the proper detailed fatigue categories for the joint of steel-concrete composite floor. With it, it is determined that the fatigue grades are appropriate because the fatigue grade A and B suggested in the study were lower than the allowable fatigue stress.

(3) It is expected that the life span of steel-concrete composite floor would be unlimited against fatigue because the fatigue test showed they did not have crack even after 2 million times of repeat load and except the points that the stress is locally concentrated owing to local deformation, it was lower than the allowable fatigue stress range.

References

1. Korea Road & Transportation Association(2005), Design Specifications for Highway Bridges(in Korean)

2. Korea Road & Transportation Association(2003), Structural Design Specifications for Concrete(in Korean)

3. Korea Institute of Construction Technology(2003), Development of Steel-Concrete Composite Bridge Decks(I)

4. Korea Institute of Construction Technology(2003), Development of Steel-Concrete Composite Bridge Decks(II)