Slab Anchor를 사용한 합성교의 거동특성 연구
The Behavior of Composite Bridge Using Slab Anchor

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ABSTRACT

본 연구는 합성교량의 경우 브라켓이나 가로보에 사용되고 비합성교량의 경우 연결재로 사용되는 스랩앵커를 Push-Out Test를 하여 실험으로 얻은 특성을 실제 소수주형모델에 적용하여 FEM해석을 통하여 거동특성을 파악 하고자 한다.

일반적으로 전단연결재 실험의 경우 콘크리트 슬래브와 강재 주형 사이에 직접 길이 방향 전단력을 작용시킬 수 있을 뿐 아니라 실험의 편리함 때문에 주로 Push-out 실험이 많이 이용되고 있다. 본 실험에서는 BS-5400에 제시된 바에 근거하여 실험체를 제작하였다. 이 실험을 통하여 탄성구간에서의 강성(k) 값을 알아내어 3D FEM 해석에 적용한다. 이때 콘크리트 바닥판과 강재와의 연결을 축 방향으로는 특정한 강성 값을 넣을 수 있는 Joint Element를 사용하여 연결시키고, 1경간 단순지지와 2경간 연속교에 대하여 연구를 수행하는데, 1경간 단순지지의 경우에는 Joint Element에 여러 강성 값과 실험을 통해 얻은 강성 값을 적용하여 합성거동을 파악하고 강성 값에 따른 합성정도를 규명하고자 한다. 또한 2경간 연속교에서는 슬랩앵커의 강성 값을 적용하여 많이 문제시되고 있는 내부지점부에 슬랩앵커를 사용하였을 때 슬래브의 인장응력이 어떤 변화양상을 나타내는지 파악 하고자 한다.

1. Introduction

In general slab-anchor is used in noncomposite bridge. Because that is not investigated ever, in this paper slab-anchor is experimented for gaining longitudinal stiffness and for plate girder FEM analysis is carried out.

2. Experiment

2.1 Push-Out test & Specimen

A aim of Push-Out test is to gain longitudinal stiffness(K) of slab-anchor. Concrete strength is about 400kgf/㎠ in order to occur rupture of slab-anchors. Specimen as follows.

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Table 1. Specimen Summary

Specimen	Concrete strength (kgf/㎠)	Dia of anchor (mm)	number of anchor	size of steel(mm)
1) SA 1-1	395	13	2	450
2) SA 1-2	388	13	2	550
3) SA 2-1	408	13	2	450
4) SA 2-2	398	13	2	550

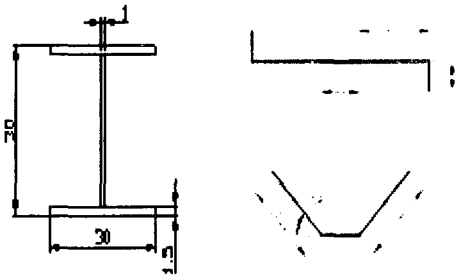


Fig 1. Anchor and Stee Plate details

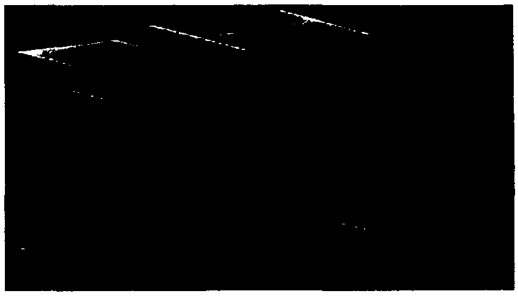


Fig 2. Specimen 3D details

2.2 Loading & Confinement

Top of the steel plate is confined and bottom of concrete is loaded by oil pressure. Transverse of concrete is confined for making a facsimile of real slab

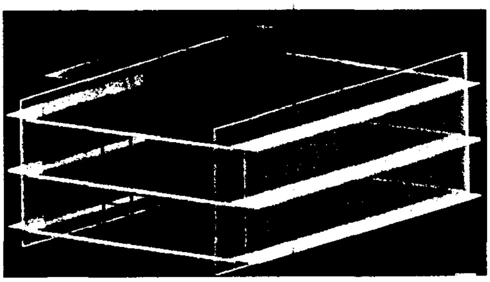


Fig 3 Condition of confinement

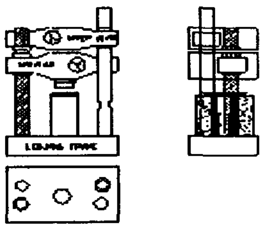


Fig 4 U.T.M.

2.3 Result of Push-Out test

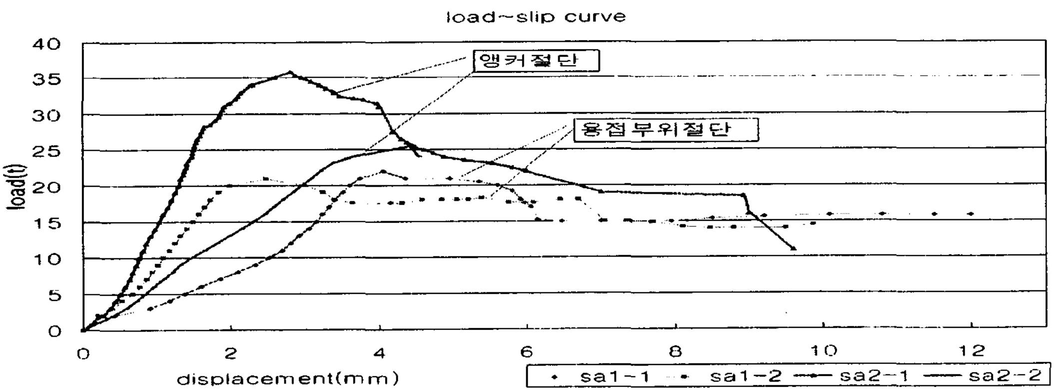


Fig 5. SA 1-1, 1-2, 2-1, 2-2 Load-Slip Curve

Load-Slip Curve of four specimen as follows Fig 5. Specimen of welding region cutting(SA 1-1, 1-2) shows lower ultimate strength than specimen of anchor cutting(SA 2-1, 2-2). Slab-anchor is not pressure-welding but pillet welding, Thus Load-Slip Curve makes difference between that of general stud experiments in plastic range.

Excluding a stiffness of SA1-1, the stiffness(K) is calculated by averaging 3 specimens because the Load-Slip Curve of SA1-1 is not linear in elastic range. It's value is 58048 *kg/cm*.

3. Parametric Study

In finite element analysis, the concrete and the girder are connected by Joint Element which the stiffness(K) is measured with experiment.

3.1 Simple Span (span=10m, number of anchor per unit length=2num/m)

In the case of 1 span simple support, the rate of a composite is investigated when the longitudinal stiffness is varied. Also, appling the experiment value(K), relative slips and strains are examined. The section property follows as

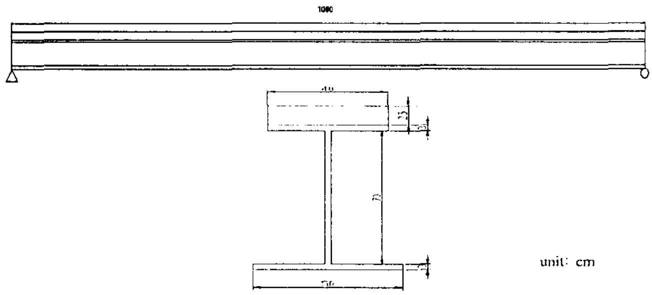


Fig 6. Section Property

Relative slips of concrete slap and plate girder are shown ,as the stiffness per unit length(Ke) is varied in Fig 7. Relative slips about the noncomposite condition ; Ke=0.02 (kg/cm/cm) and the composite condition : Ke=20000 0(kg/cm/cm) are plotted in Fig 8. Increasing Ke, the relative slip is converged on zero. On the other hand, the appled experimental stiffness per unit length, which is 1160.96(kg/cm/cm) is close to noncomposite behavior.

However, the more anchors per unit length, the more degree of composite. So, Ke is not an absolute value. The Strain Distribution for the stiffness per unit length(Ke) is shown in Fig 9. Based on Fig 7, the classification of composite degree is proposed in Table 2.

The stiffness of a general stud is 100000(kg/cm) which is calculated by Oehler formula. When it is applied in this finite element model, Ke is 20000(kg/cm/cm). It is represented that the Oehler formula's stiffness is very close to perfect composite. Considering that the general interval of studs is about 30cm, the classification of composite degree follows as Table 2.

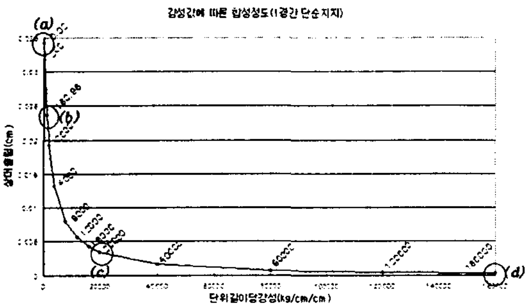


Fig 7. The Relative Slip for Ke (1Span Simple Support)

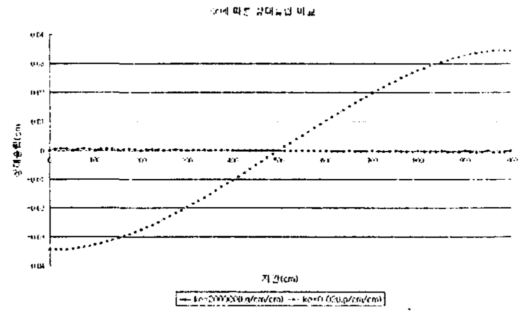
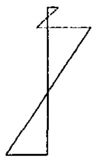
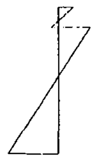


Fig 8. The Relative Slip for Total Span (1Span Simple Support)



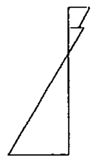
ε_{cu}	-7.14e^-6
ε_{cl}	7.14e^-6
ε_{su}	-26.27e^-6
ε_{sl}	26.27e^-6

(a) Ke = 0.02(kg/cm/cm)



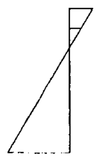
ε_{cu}	-9.565^e-6
ε_{cl}	4.406^e-6
ε_{su}	-19.97^e-6
ε_{sl}	30.51^e-6

(b) Ke = 1160.96(kg/cm/cm)



ε_{cu}	-13.79^e-6
ε_{cl}	-6.704^e-6
ε_{su}	-10.3^e-6
ε_{sl}	38.99^e-6

(c) Ke = 20000(kg/cm/cm)



ε_{cu}	-19.07^e-6
ε_{cl}	-9.729^e-6
ε_{su}	-9.73^e-6
ε_{sl}	51.04^e-6

(d) Ke = 200000(kg/cm/cm)

Fig 9. The Strain Distribution for Ke (1Span Simple Support)

Table 2. the classification of composite degree for Ke

Composite Degree	The Stiffness per Unit Length(Ke)
Noncomposite	Ke<4000
Partial Composite	4000<Ke<40000
Perfect Composite	Ke>40000

3.2 Two-Span Continuous Composite Girder(span=20m, number of anchor per unit length=2num/m)

In the case of two-span continuous composite girder, the rate of a composite is investigated As the longitudinal stiffness is varied. Also, gradually appling the experimental value(K) from intermediate support to the both end, relative slips, strain, stress, and displacement are examined. The section property is in Fig 10, 11.

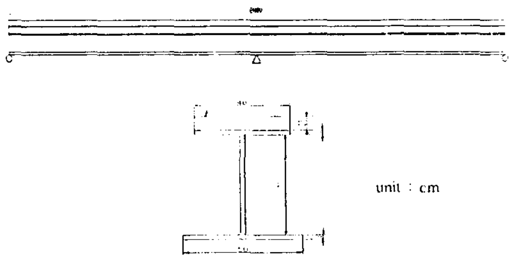


Fig 10 Section Property

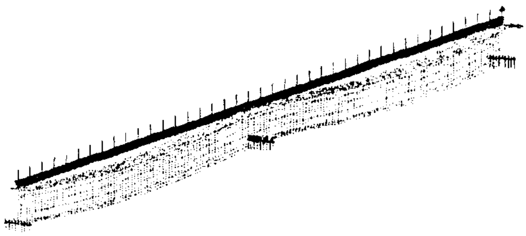


Fig 11 Load & Support

Relative slips of concrete slap and plate girder are shown in Fig 12, as the stiffness per unit length(Ke) is varied. Fig 12. resembles Fig 7. shapely and quantitatively. Also, an aspect of deflections is shown in Fig 13. As the degree of composite increases, deflection decreases.

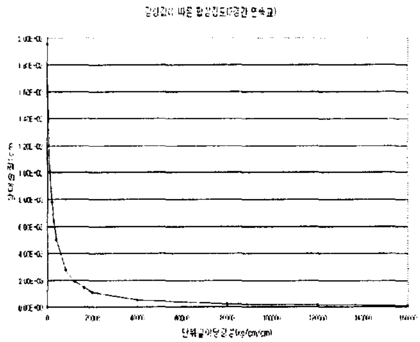


Fig 12. The Relative Slip for Ke (Continuous Composite)

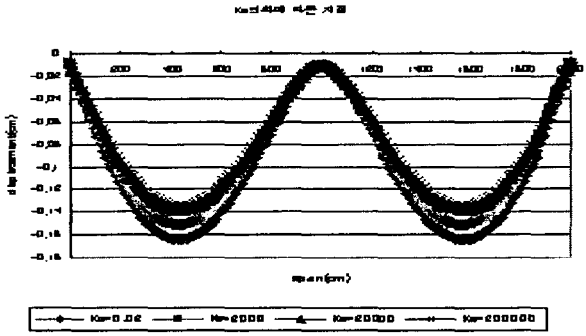


Fig 13. Deflection for Ke (Continuous Composite)

Gradually appling the experimental value(K) from intermediate support to the both end, changes of tensile stresses are examined in Fig15. This procedure is shown in Fig 14.

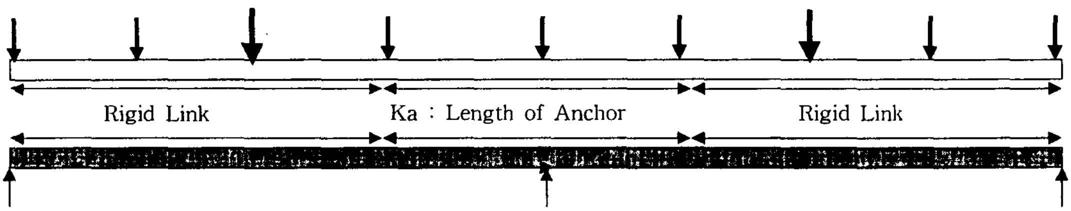


Fig 14. Ka is Length Appling The Experimental Value(K)

4. Conclusion

In this paper, the evaluation of initial shear stiffness of slab-anchor in composite bridges is obtained from Push-Out specimen. Also, finite element analyses which uses the initial shear stiffness of slab-anchor got the experiment are carried out on simple composite girder and continuous composite girder. Futhermore, the degree of composite according to various shear stiffness are investigated and the classification according to the degree of composite is proposed.

(1) Load-Slip Curve of four specimen follows as Fig 5. Specimen of welding region cutting(SA 1-1, 1-2) shows lower ultimate strength than specimen of anchor cutting(SA 2-1, 2-2). Slab-anchor is not pressure-welding but pillet welding, Thus Load-Slip Curve makes difference between that of general stud experiments in plastic range.

(2) The experimental stiffness(K) is 58048 *kg/cm* in elastic range.

(3) As the longitudinal stiffness is varied, the classification of composite degree is proposed in Table 2.

(4) In case of the two-span continuous composite girder, the degree of composite resembles Simple Span. As Ka is increased at intermediate support, tensile stress is rapidly decreased at Ka=900cm

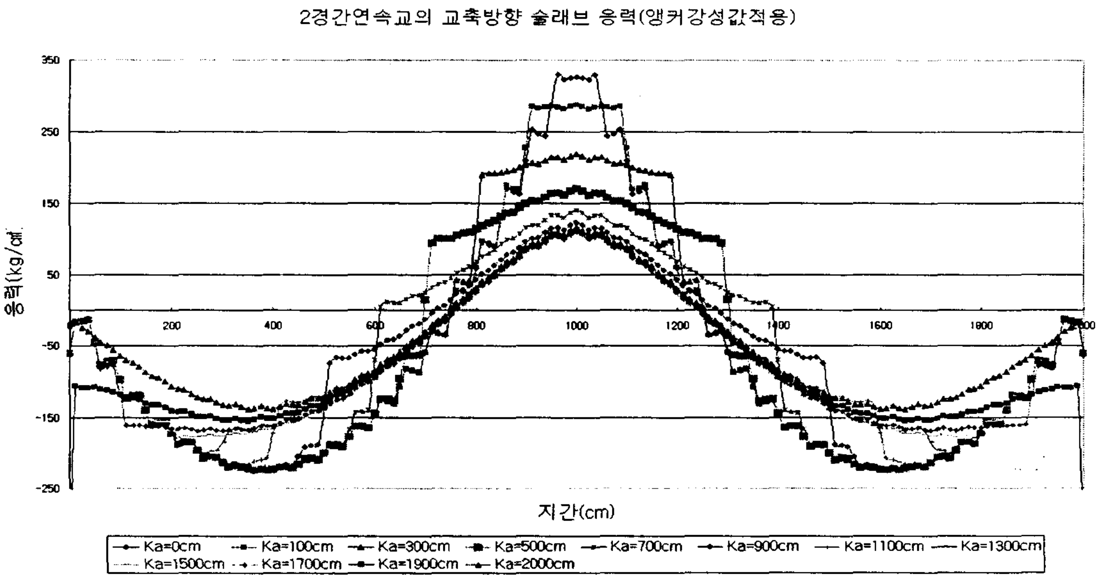


Fig 15. Longitudinal stresses for Ka

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