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## Reinforcing Bar Grouting Method for Connecting Precast Reinforced Concrete Structural Members

Méthode d'injection des armatures en acier pour la liaison d'éléments préfabriqués en béton armé

Injektion von Bewehrungs-Stäben für die Verbindung von vorgefertigten Stahlbeton-Bauteilen

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### 1. INTRODUCTION

"Reinforcing Bar Grouting Method" to be used for jointing and assembling the precast reinforced concrete structural members is shown schematically in Fig.1. The precast concrete elements are arranged the holes beforehand to be inserted the reinforcing bar. When assembling the elements, the re-bar are inserted into the corresponding holes. Then the cement mortar is grouted in the hole to make these elements into a composite unit. It does not need in-situ cast concrete.

This method may be applied to various types of connections making a good use of this method concept. Therefore the structural practicability of this method was experimentally examined. After that, this method was applied to several precast concrete structures.

This paper shows the results of the fundamental experiments.

### 2. BOND TEST

The bond strength of the re-bar fixed by grouting had been considered to control the structural character of the connection by this method. Therefore the pull-out bond tests, referring to the test method of "ASTM C324-57T", were carried out to know the significant factors affecting the bond strength.

16 specimens made by grouting method were prepared under various conditions, i.e. using an aluminum powder admixture with or without expansive cement, making the hole with smooth surface or flexible sheath, grouting vertically or horizontally etc.. And 6 specimens with a directly embedded bar were also prepared for comparison.

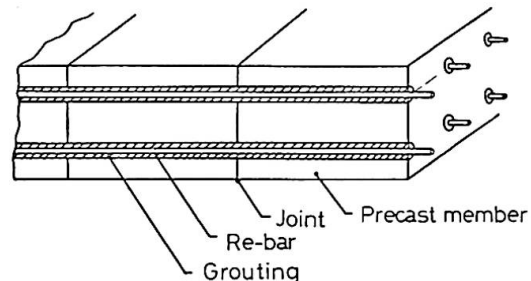


Fig.1 "Reinforcing Bar Grouting Method" concept

The compressive strength of the cement mortar and the concrete used for specimens were about  $270 \text{ kg/cm}^2$  and  $335 \text{ kg/cm}^2$  respectively at the test, 7 days after grouting. The bond strength was measured in each specimen when the slippage of bar at the loaded side was 0.1 mm, 0.2 mm and the load reached to the maximum respectively. According to the variance analysis concerning the effect of the abovementioned factors for these strengths, each factor had a slight influence. The bond strength of  $\phi 22$  mm deformed bar fixed by grouting was about  $80 \text{ kg/cm}^2$  (at 0.1 mm slippage) and  $150 \text{ kg/cm}^2$  (max.) which were same with or more than that of a directly embedded bar. This confirms that the sufficient pull-out bond strength can be obtained using the conventional cement mortar grouting.



Phot.1 Inside of specimens after pull-out bond test

### 3. BENDING TEST

The re-bar in this method is generally used for connecting and it has possibility to be utilized as the main reinforcements in precast reinforced concrete structural members. Therefore the bending tests of beam were carried out to know the structural character of the joint and the member.

Dimensions, loading capacities and material characteristics of the beam specimens were as follows;

$$h=30\text{cm}, b=20\text{cm}, d=25\text{cm}, d'=5\text{cm}, A_g/bd=A'_g/bd=0.011,$$

$$L=200\text{cm}, l=150\text{cm},$$

$$M_d=2.25\text{t-m (for design calculated as } \sigma_s=1800\text{kg/cm}^2)$$

$$M_u=5.97\text{t-m (for ultimate calculated as } \sigma_s=3600\text{kg/cm}^2)$$

where

$$f_c \doteq 340\text{kg/cm}^2 \text{ (for concrete when tested)}$$

$$f \doteq 240\text{kg/cm}^2 \text{ (for mortar when tested)}$$

$$f_y=3600\text{kg/cm}^2 \text{ (for } \phi 19\text{mm deformed bar yielding)}$$

4 types of beam specimens, 2 specimens to each type, were prepared for testing.

#### (1) No-joint beam

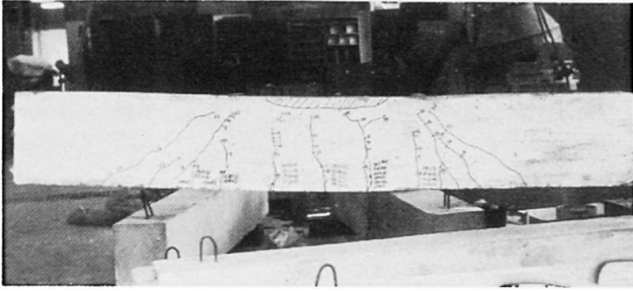
TYPE-A ; The no-joint beam specimen with the reinforcements fixed by grouting

TYPE-A' ; The conventional beam specimen with the directly embedded reinforcements (for comparison)

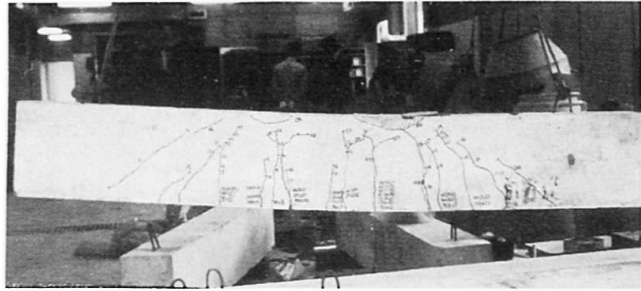
Between both types of specimens under same loading, there was no notable difference in crack pattern and crack width.(Phot.2 and Phot.3) This means that the bond strength of the re-bar fixed by grouting in beam under bending is almost same as that of the conventional beam. In other words, the bending character of the beam made by the grouting method can be insured as same as the conventional one.

#### (2) Beam with a joint

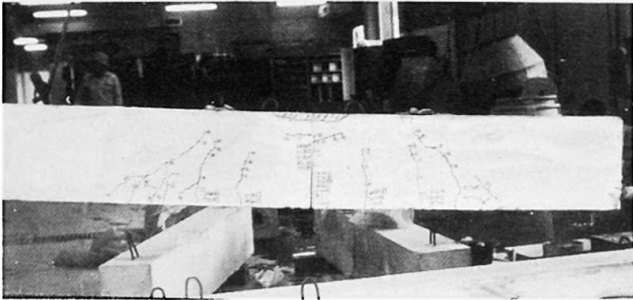
TYPE-B ; The precast beam specimen connected with two elements by the re-bar grouting method



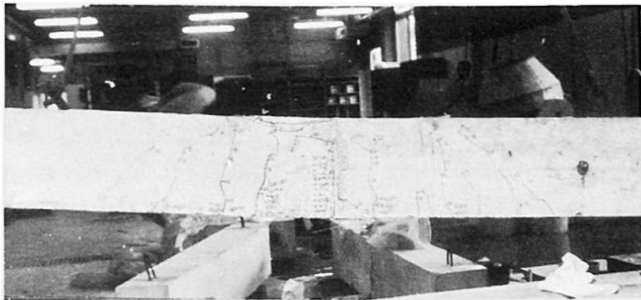
Phot.2 TYPE-A Specimen



Phot.3 TYPE-A' Specimen



Phot.4 TYPE-B Specimen



Phot.5 TYPE-B' Specimen

TYPE-B' ; The conventional beam specimen arranged a construction joint (for comparison)

In both types of specimens, the first crack occurred at the joint, which developed as the most significant crack in same manner. (Phot.4 and Phot.5) The residual deflection after removing the designed load was also similar. Therefore it was known that the re-bar grouting joint could be treated like a construction joint.

(3) Comparison of beam with and without joint

The degradation of flexural rigidity as bending moment increased is shown in Fig.2. The solid line (A) is for the TYPE-A specimen including the TYPE-A' specimen; the dotted line (B), TYPE-B including TYPE-B'.

The dotted line is lower in the range of small load than the solid line, however it is almost same at the designed load for the transformed section by the traditional reinforced concrete beam theory. And both lines show the same ultimate strength.

4. CONCLUSION REMARKS

Through the fundamental experiments, it was known that this method is available for practical use, on condition that the detailed checks depending on circumstances are added. This method may be applied to jointing and assembling the various precast reinforced concrete structural members. The method arranged by prestressing may also effective.

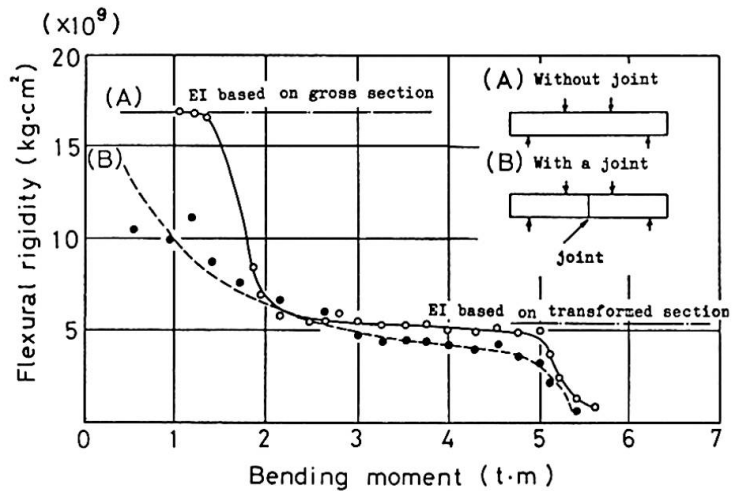


Fig.2 Flexural rigidity of beam with and without joint

**SUMMARY**

The reinforcing bar grouting method is used for connecting the precast reinforced concrete elements by means of grouted reinforcements. According to the pull-out bond tests and the bending test of beam, this method may be available for practical use depending on circumstances.

**RESUME**

Cette méthode d'injection des armatures en acier est utilisée pour la liaison d'éléments préfabriqués, en béton armé. D'après les essais d'adhérence par arrachement et les essais de flexion, cette méthode peut être utilisée en pratique, dans certaines circonstances.

**ZUSAMMENFASSUNG**

Die Injektion von durchgehenden Bewehrungs-Stäben für die Verbindung von vorgefertigten Stahlbeton-Bauteilen erweist sich aufgrund von Haftversuchen und einer Prüfung der Verbindung auf Biegung als geeignete Lösung.