Bond Strength of Self-Comacting Mortar

BOND STRENGTH OF SELF-COMACTING MORTAR

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***ABSTRACT*:** The factors for the bond strength of self-compacting mortar as repairing material to the hardened concrete were experimentally examined. Both tensile and shear bond strength were examined. It was found that the dominant factor for the bond strength was the supply of water for the hydration of cement rather than the water to cement ratio of the mortar.
KEYWORDS: self-compacting concrete, self-compacting mortar, tensile bond strength, shear bond strength

1. INTRODUCTION

The necessity for cheap repairing material for the conventional concrete structures is increasing. To make the repairing material cheap, only the common materials should be used. Self-compacting concrete is desirable for the necessity because no special material is employed.

As the repairing material for the conventional concrete structures, the bond strength to the existing hardened concrete is indispensable.

However, such kind of research on the bond strength has not been done, especially for the mortar or concrete without using any special admixture like polymer mortar.

The purpose of this study is to clarify the factor for the bond strength of self-compacting mortar to the hardened concrete.

2. WATER TO CEMENT RATIO ON BOND STRENGTH

From the commonsense of the concrete engineering, the dominant factor for the strength is water to cement ratio. Therefore, at first the relationship between the water to cement ratio and the tensile bond strength was experimentally obtained (**Fig. 1**). Also, the relationship between the water to cement ratio and the shear bond strength was experimentally obtained (**Fig. 2**). Higher cement to water ratio (C/W) resulted in the lower shear bond strength. It is possible that the influence of the water to cement ratio on the bond strength was not so large as that of the jointless specimen of concrete.

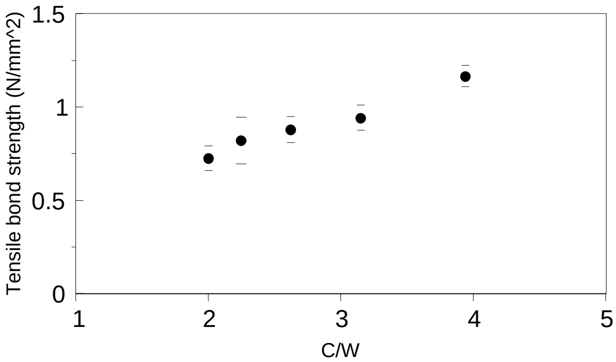

Fig. 1 Relationship between C/W and tensile bond strength at the age of 3 days by shield curing: average value and standard deviation

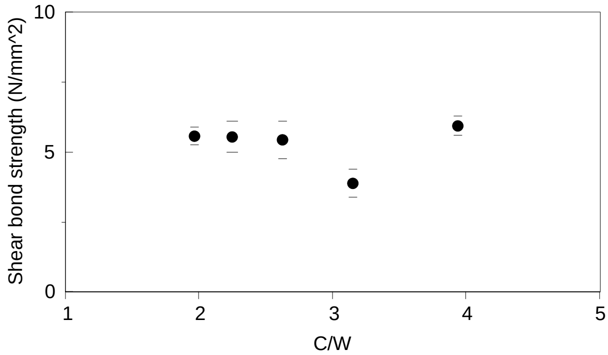

Fig. 2 Relationship between C/W and shear bond strength at the age of 7 days by shield curing

3. METHOD OF CURING ON BOND STRENGTH

As the reference, the tensile and shear strength of the jointless specimen of concrete were experimentally obtained (**Fig. 3** and **Fig. 4**).

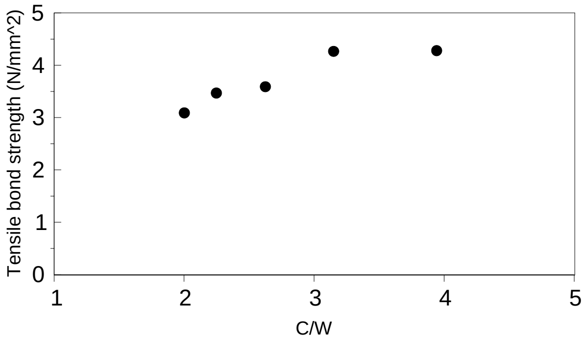

Fig. 3 Tensile strength of the jointless specimen of concrete by shield curing at the age of 3 days: tensile split-cylinder test

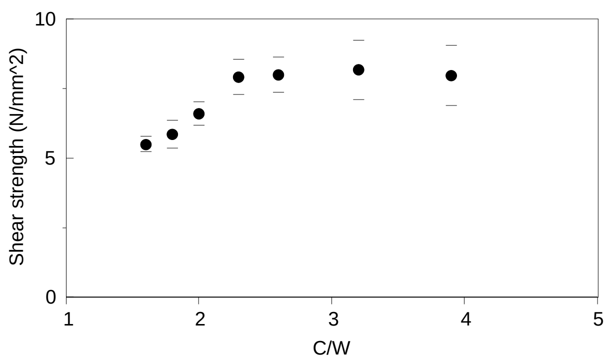

Fig. 4 Shear strength of the jointless specimen of concrete by shield curing at the age of 7 days

Higher cement to water ratio did not result in the high strength in case of the shield curing. That may be due to the shortage of water for the hydration of cement and then that may be the case with the bond strength.

The tensile bond strength was compared by between shield and water curing (**Fig. 5**). The tensile bond strength by water curing was almost twice as much as that by shield curing.

However, water curing did not promote the tensile bond strength of the mortar with low C/W of around 2. That may be because it had sufficient water for hydration of cement.

It is possible that the dominant factor for the bond strength was the supply of water for hydration of cement rather than the water to cement ratio itself.

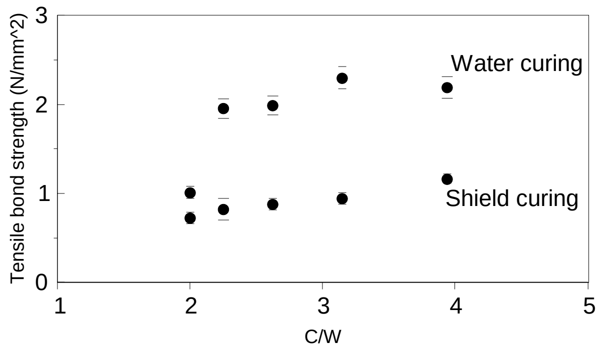

Fig. 5 Water curing promoted tensile bond strength; Upper: water curing; lower: shield curing

Also, the bond strength of the jointless specimen of concrete by between water and shield curing was compared (**Fig. 6**). The promotion rate of the tensile strength by water curing was small compared with the tensile bond strength. The necessity for water for hydration of cement was verified especially for the bond strength.

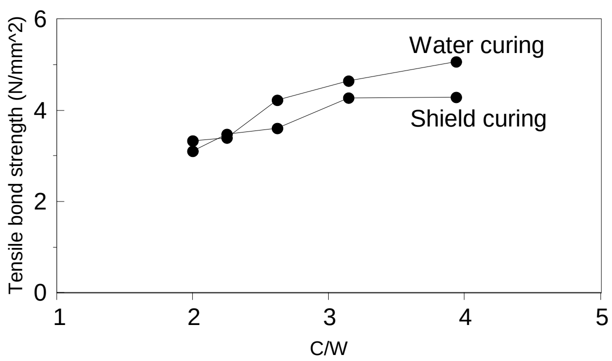

Fig. 6 Less difference in tensile strength between water and shield curing than tensile bond strength at the of 3 days

4. SUPPLY OF WATER FOR HYDRATION OF CEMENT ON BOND STRENGTH

Some portion of cement was replaced with limestone powder and the relationship between the cement to water ratio (C/W) and the tensile bond strength was obtained (**Fig. 7**). The volumetric ratio of water to powder (= cement + limestone powder) was constant of 100%.

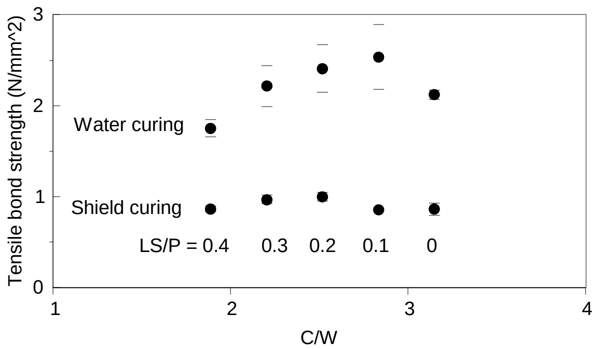

Fig. 7 Promoted hydration of cement by limestone powder; LS/P: volumetric ratio of limestone powder to total powder

Despite of the replacement with limestone powder and then the reduction in the cement content of the mortar, the tensile bond strength was almost constant in case of shield curing and promoted in case of water curing. That may be because the retained water by limestone powder was consumed for the hydration of the cement and then it promoted the tensile bond strength.

5. CONCLUSIONS

The dominant factor for the bond strength of self-compacting mortar to the base material concrete was experimentally examined for both tensile and shear strength. The conclusions are summarized as follows:

(1) Higher cement to water ratio did not always result in the higher bond strength compared with the strength of jointless specimen of concrete.

(2) Water curing promoted the tensile bond strength remarkably from that of shield curing. Also, the replacement of cement with limestone powder promoted or kept the tensile bond strength despite of the reduction in the cement content of the mortar.

(3) It can be concluded that the dominant factor for the bond strength was the supply of water for the hydration of cement rather than the water to cement ratio.

It was found that the sufficient supply of water for the hydration is indispensable in order to make the self-compacting mortar practical in the repairing work of the existing concrete structures, especially to promote the tensile bond strength at this moment. For example, the tensile bond strength of the polymer cement mortar was almost 2 N/mm^2.

MATERIALS IN USE

Cement: ordinary portland cement (specific gravity: 3.15)

Fine aggregate: mixture of limestone crushed sand (specific gravity: 2.69; F. M.: 2.73) and sea sand (specific gravity: 2.59; F. M.: 2.22) :(8:2 by volume)

Superplasticizer: Poly-carboxylate type of superplasticizer

MIX PROPORTIONING OF SELF-COMPACTING MORTAR

Fine aggregate content in mortar: 45% by volume

Dosage of suerplasticizer: adjusted to obtain the mortar flow value of 290 to 310 mm

FLOWABILITY OF SELF-COMPACTING MORTAR

The flow value of the mortar was 290 to 310 mm so that the sufficient contact with the existing concrete may be obtained and also the segregation between paste and mortar may be prevented (**Fig. 8**).

BASE MATERIAL CONCRETE TO WHICH MORTAR WAS BONDED

The base material concrete to which the self-compacting mortar was bonded was conventional concrete of W/C of 45%. To eliminate the influence of the hydration of the based material concrete itself on the bond strength, only the concrete specimen with the age of over 28 days was employed. The compressive strength was around 44 N/mm^2 at the age of 28 days.

The interface to the mortar was grinded by the grinding machine for the top and bottom surface of the specimen for compressive strength test.

The base material concrete was in water until just before the casting of the self-compacting mortar and the interface was wiped just before the casting of the mortar.

Fig. 8 Flow of self-compacting mortar of around 300 mm

SPECIMEN FOR BOND STRENGTH TEST AND CURING

The conventional specimen of the cylinder of ϕ100 * 200 mm was employed for the convenience and the compatibility with the conventional strength testing methods. The lower portion was the base material concrete and self-compacting mortar was cast to the upper portion without vibration (**Fig. 9**).

No segregation was observed in all the mixes of the mortar in this series of experiment.

Fig. 9 Specimen for bond strength: common in both tensile and shear bond strength; upper: self-compacting mortar; lower: base material concrete (conventional concrete)

In case of shield curing, the mould having the specimen was wrapped after the casting of the mortar until the strength test. In case of water curing, the mould was removed at the age of 1 day.

TENSILE BOND TESTING METHOD

The conventional tensile split-cylinder test is not suitable for the tensile bond strength test because of the existence of the joint between the base material concrete and the self-compacting mortar. The strength of the joint itself has to be tested to evaluate the repairing material. So, chuck type of testing apparatus was employed, which the authors have newly developed (**Fig. 10** and **Fig. 11**).

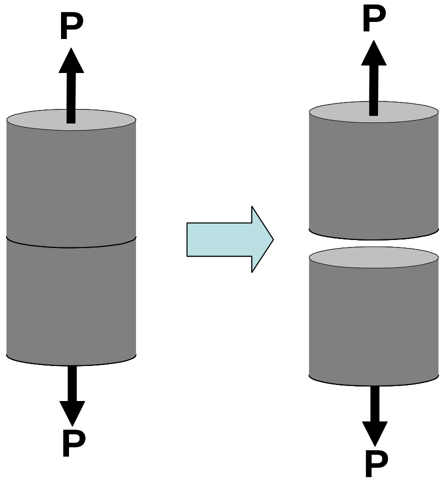

Fig. 10 Concept of direct tensile test

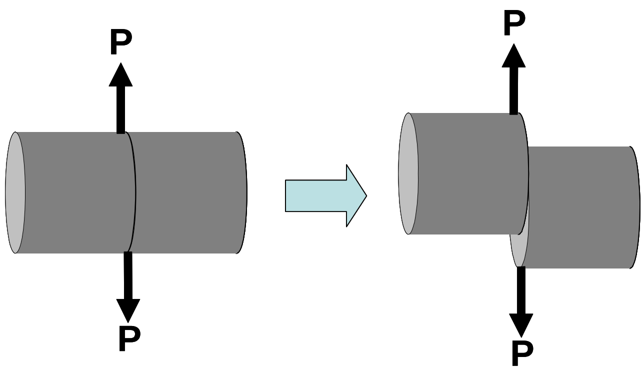

Fig. 12 Concept of direct pure shearing apparatus: not by compression but by tension

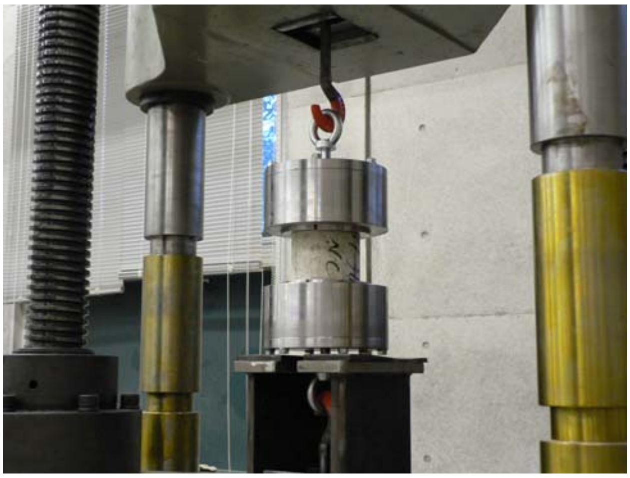

Fig. 11 Chuck type of tensile testing apparatus

Fig. 13 Direct pure shearing testing apparatus: not by compression but by tension

This testing apparatus was employed in the tensile bond strength test only in this research. The tensile strength of the jointless cylinder of concrete was obtained by the conventional split-cylinder test.

SHEAR STRENGTH TESTING METHOD

A direct pure shear testing apparatus was employed, which the authors have newly developed. The concept of the testing method and the testing apparatus itself are shown in **Fig. 12** and **Fig. 13**.

Fig. 14 Shear failure of jointess specimen of concrete by the apparatus

FAILURE MODE OF TENSILE BOND TEST

In this research, no breaking of the base material concrete or self-compacting mortar was observed in the tensile bond strength test. All of the specimens were failed on the interface between the base material concrete and the elf-compacting mortar in this series of experiment.

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