Mechanism Clarification and Knowledge Formation of Unique Behavior of Chemically Prestressed Concrete for Efficient Use of Expansive Concrete

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***ABSTRACT*:** The objectives of this paper are to understand expansive concrete by discussing the mechanism of unique behaviors and to propose appropriate way to use expansive additive so that average engineers can utilize it properly. First, the mechanism of nonlinear behavior of expansive concrete is discussed. From the observations of fracture surface of cement paste specimen, it's confirmed that one of the causes of the nonlinear behavior is micro cracking due to strain variation introduced by expansive action since micro cracking causes plastic deformation and stiffness reduction. Experiments using different types of gravel and their strain during volumetric expansion indicate that another cause of the nonlinear behavior is the debonding on the gravel surface. Debonding on the rebar surface is also confirmed in the test using reinforced cement paste specimen with expansive additive. The debonding on rebar, however, is prevented by using gravel since gravel changes strain distribution in the specimen. It can be said that using gravel and deformed bar constrain debonding on the rebar surface in chemically prestressed concrete. Based on the above results, some points which should be kept in mind when using expansive additive are pointed out.

KEYWORDS: Expansive concrete, shrinkage compensation, self prestress

1. INTRODUCTION

The use of expansive additive is one of the most effective methods to reduce shrinkage cracking in concrete members. Adding expansive additive to concrete causes volume increase and the shrinkage is compensated. When more expansive additive is used and restraint is given to concrete members, prestress is introduced (Chemically Prestressed Concrete, CPC) and the mechanical performance is improved. So far, expansive additive has been used to where its effect has been known empirically since its performance changes much depending on curing method, temperature, etc. Nowadays, as the shipping volume of expansive additive increases, it has been used for various members under a wide range of condition, and in some cases, it is reported that expansive additive doesn't work effectively to control cracking. As a result, in Japan, and also in some other countries, some questions about the effectiveness of expansive additive are raising. Regarding CPC, although the mechanical performance is improved, evaluation method of its behavior is not fully established yet. Also, CPC with much amount of expansive additive is known to show unique behaviors, such as nonlinear behavior, better tension stiffing effect etc., however, the mechanism is not clarified yet. It can be said that the above problems are referable to incomplete understanding of expansive concrete. In order to utilize this complicated material appropriately, it is necessary to understand its property. The objectives of this paper are to understand the mechanism of unique behaviors of expansive concrete, and based on the mechanism, to note some points which should be kept in mind when using expansive additive so that average engineers can utilize it properly.

2. PAST RESEARCHES ON CEMENTITIOUS MATERIAL WITH EXPANSIVE ADDITIVE

2.1 General effect

Since it is the main purpose to use expansive additive, the effect of shrinkage compensation has been reported by many researchers, e.c., as summarized in a report by Japan Concrete Institute. When concrete shrinkage is reduced, strain of rebar after cracking decreases, in other words, crack width is reduced. Some researchers have reported that CPC shows better mechanical performance because of prestress, and also, higher mass transfer resistance since it has smaller pore size distribution. On the other hand, some reports say that expansive additive is not usually effective to control cracking. For example, a report by Japan Concrete Institute says about applying to massive concrete that although expansive additive reduces crack width, it is difficult to avoid cracking itself. On the other hand, a paper in the above report said that expansive additive reduced number of cracks, however, the crack width was not reduced.

2.2 Unique behaviors of CPC

2.2.1 Nonlinear behavior

Okamura conducted a series of bending test of concrete beams at the age of 28 days. The load-concrete strain curves showed linear behavior until cracking occur in normal concrete, however, nonlinear behavior in expansive concrete. Hosoda et al. conducted uniaxial tension test using young mortar and cement paste, and reported that specimen with expansive additive showed nonlinear behavior such as decrease in stiffness and plastic deformation, and more nonlinearity in expansive mortar than expensive paste. Hosoda et al. also conducted repetitive direct tension test on mortar specimen and confirmed that nonlinearity decreased as the material age increased, and finally, almost elastic behavior at the age of 21 days. The points of the above reports are summarized as follows: clear nonlinear behavior in bending test on expansive concrete even at the age of 28 days, on the contrary, nonlinearity disappeared as the material age increased in tensile test on expansive mortar. These behaviors indicate that the factors of nonlinearity can be divided into two; affected and not affected by aging.

2.2.2 Performance improvement after drying

Tsuji conducted bending test of concrete beams changing drying period and reported that in normal concrete, the cracking moment decreased as the drying proceeds. On the other hand, in expansive concrete, it decreased first, however, recovery occurred later and eventually, the cracking moment of expansive concrete became larger than that before drying.

2.2.3 Bonding property

Ishimatsu et al. conducted uniaxial tension test and reported that expansive concrete showed higher peak stress than normal concrete, and also, stress release after cracking was relatively slow. As a cause of the above behavior, Hosoda et al. pointed to anti-localization of damage in expansive concrete. Sahamitmongkol et al. conducted uniaxial tension test with mortar and reported that the bond stress at the center of the specimen became zero in expansive mortar.

3. MECHANISM OF UNIQUE BEHAVIORS

In this chapter, mechanisms of some unique behaviors are discussed to understand the property of cementitious material with expansive additive.

3.1 Micro cracks in cement paste

3.1.1 Fracture surface after flexural failure

First, the effect of expansive action to cement paste was examined. The mix is shown in Table 1. In

Table 2, the material properties used in this paper are shown. The size of the prism specimen is 120mm in length, 10mm in width and 20mm in height. The cement paste was cast in steel mold and demolded 24 hours later, and cured under water at the temperature of 20 degrees Celsius without restraint. Different curing conditions were given to some specimens; under cold water, in sealed condition or without demolding. Flexural failure was given to the above specimens at the age of 7 days after casting, and for some specimen, at the age of 28days.

Flexural fracture surfaces at the age of 7 days are shown in Fig.1. N shows smooth surface, however, rough surface in expansive paste specimen and it gets more pronounced as the amount of expansive additive increases, i.e., in E1 only near tensile face is rough but whole surface in E2. Fracture surfaces at the age of 28 days are shown in Fig.2. It can be seen that the surfaces of E1 and E2 become smooth compared with those in Fig.1. Difference of the fracture surfaces due to curing condition can be seen in Fig.3 and Fig.4. When the curing temperature is low, 5 degree Celsius, the whole fracture surface in E1 also become rough. When restraint is given by steel mold, the roughness of the surface is reduced. The above results show

Table 1 Mix proportion of cement paste

Case.	W/B (%)	Unit content(kg/m^3)		
		W	C	EA
N	40	557	1383	0
E1	40	557	1279	104
E2	40	557	1176	207

Table 2 Material properties

Cement	Normal cement（SG:3.15）
Expansive additive	Compound type of ettringite and lime（SG:2.70, recommended amount of use: 20kg/m^3）
Sand	SG:2.62, FM:2.74
Gravel	SG:2.72, FM:6.67, Max. size: 20mm

(a)N (b)E1 (c)E2

Fig.1 Fracture surface
（age: 7days, cured under water）

(a)N (b)E1 (c)E2

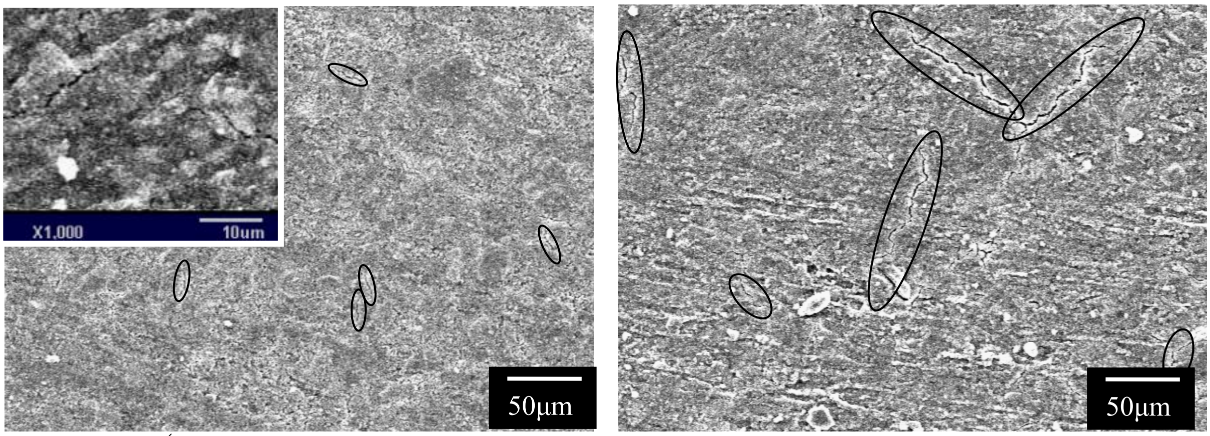
Fig.2 Fracture surface
（age: 28days, cured under water）

(a)E1 (b)E2

Fig.3 Fracture surface
（age: 7days, cured under cold water）

(a)No restraint (b)Restrained

Fig.4 Fracture surface
（age: 7days, E2, sealed curing）



(a)N（magnification of 1000 times is shown at the upper left）

(b)E2

Fig.5 Results of SEM analysis with magnification of 300 times

that the property of fracture surface depends not only on the volume of expansive additive, but also material age and restraint condition. Fig.5 is the results of SEM analysis with grinded intact specimens. The length of micro cracks in N is around 10µm in length but 100µm in E2. Hosoda et al. pointed out that expansive additive causes strain variation and micro cracks in cement paste. The authors confirmed numerically that under deformation, micro cracking occurred where tensile stress is introduced by expansion. It is probable that the larger damages in E2 in Fig.5 are caused by the expansive action.

3.1.2 Discussion on mechanism of different fracture surface

Based on the results in the previous item, the effect of expansive action to cement paste is discussed. The width of Fracture Process Zone (FPZ) depends on the size of the constituent material. For example, Bazant said that FPZ in concrete was the three times bigger than the maximum gravel size and Schlangen et al. reported concrete had larger FPZ than mortar. In cement paste, the width of FPZ will be several 10µm since cement paste is composed of hydrates of around 10µm in diameter and, as a result, in the observation, the fracture surface looked smooth macroscopically. On the other hand, in expansive cement paste, there were micro cracks of 100µm in length and that caused larger FPZ, probably several 100µm and the fracture surface become rough.

Landies et al. reported that in bending test, until the maximum load, broad FPZ was formed near tension side. At the peak load, however, localization of damage occurred and crack propagated with smaller FPZ. It is also reported that increase in loading rate reduced the size of FPZ. In the bending test in this paper since the displacement control was not very precise, crack propagated very quickly after the localization of damage. Based on the above points, in the test in this section, it can be said that micro cracks were easy to develop near tension side but not at the middle. As a result, in E1, the fracture surface near tension side became rough because of larger micro cracks and FPZ but smooth at the middle of the specimen. The fracture surface property indicates that micro cracks were developed under deformation.

In E2, the whole fracture surface was rough because micro cracks of 100µm in length already existed before loading because of much amount of expansive additive and the propagation of macro crack was interrupted by them, resulting in rough fracture surface.

At the age of 28days, the fracture surface became smooth in E1 and E2. Strain variation

Table 3 Mix proportion of concrete

Case.	W/B (%)	Unit content(kg/m^3)					
		W	C	EA	G	S	AE
N	45	180	400	0	915	814	C×0.002%
E	45	180	370	40	915	814	C×0.002%

introduced by expansive action is reduced by hydration, since new hydrates are produced without strain, and they became dominant as hydration proceeds. As a result, development of micro cracks was reduced resulting in smooth surface.

When the curing temperature is low, because of the difference in the activation energy, expansive action becomes relatively slow compared with the reaction of cement and expansion consequently gave damage to paste and micro cracks developed much. When restraint is given, since volumetric change is reduced, the strain variation by expansive action is also reduced. As a result, it becomes difficult for micro cracks to develop and the fracture surface became smooth. The above observation suggests it is probable that the micro cracks cause nonlinear behavior. As the material age increases, nonlinear behavior is reduced since strain variation and micro cracks introduced by expansive action is reduced by hydration. Based on the mechanism, it can be said that in CPC members, nonlinear behavior due to micro cracks will be not remarkable because there are some restraint by rebars or other members and that reduces micro cracks.

3.2 Nonlinear behavior due to micro debonding

3.2.1 Gravel strain in expansive concrete

In this section, the effect of expansive action on gravel is discussed. When no restraint is given to expansive concrete, like a hole at center of a coin become larger by thermal expansion, it is probable that and debonding occur between gravel and paste. On the contrary, when very strong restraint is given by steel pipe etc, gravel might get compression. Though, it's not clear what kind of action occur to

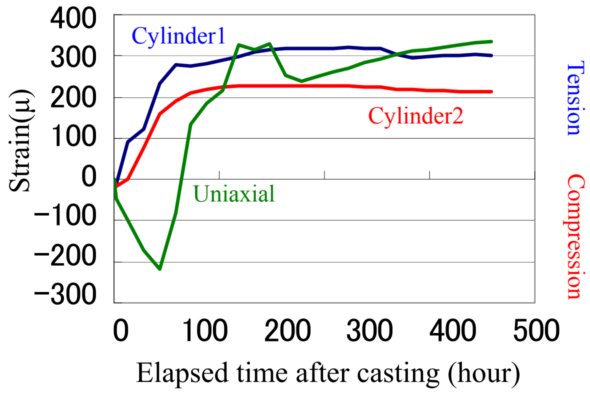


Fig.6 gravel strain in expansive concrete

Table 4 Mix proportion of expansive mortar

case.	W/B (%)	Unit content(kg/m^3)			
		W	C	EA	S
EM	40	355	802	89	891

gravel in general RC member, the degree of restraint is middle. In order to examine that, strain of gravel was measured; three pieces of gravel were split and grinded inside, and after that, strain gages were attached inside of them and they were put together by adhesive. Two piece of gravel with strain gage were put in expansive concrete cast in a cylinder steel mold and the other one in an uniaxially confined prism specimen, with the reinforcement ratio of 3%. Concrete mix and measured strain are shown in Table3 and Fig.6, respectively. All measured strain shows tensile strain although one data, gravel in an uniaxially confined specimen, shows compression in very young age. It is probable that the expansive mortar around gravel was not hardened enough and deformed by heterogeneous restraint force resulting in compression of gravel. The above results show that gravel gets tension even under relatively strong restraint, therefore, it is likely even more in general RC members.

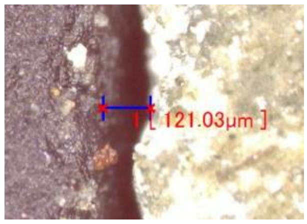
3.2.2 Test with simulated concrete

In order to examine the effect of expansive action to gravel from another point of view, spherical and flat marbles were used instead of gravel in the next test. They were mixed with expansive mortar, the mix is shown in Table 4, so that the volume fraction of marbles became 40%. The simulated concrete was cast in steel mold of 160mm in length and 40mm in width and height, and three dimensional restraint was given with steel plates and clamps. After 7days of sealed-restrained curing, the clamps and the molds were removed and the specimen was cut at the middle perpendicular to the axial direction. The cutting surfaces are shown in Fig.7 and Fig.8. There is gap along the whole circumference of spherical marbles, but only at the edges of flat marbles. When expansion takes place, debonding occur, however, if strong confinement is given, the paste around gravel get deformed. In the case of spherical marbles, paste around them got compression in radial and also circumferential direction and not easy to be deformed. As a result, paste kept its shape during expansion and debonding occurred along the whole circumference. On the other hand, in the case of flat marbles, it is likely that the paste near flat part deformed in flexural manner as shown in Fig.9 and, consequently, debonding occurred only at the edges of flat marbles.

3.2.3 Flexural behavior with Gravel of different shape

In the previous section, it is confirmed that the degree of debonding is affected by gravel shape. In this section, the results of repetitive bending test using crashed gravel and marble gravel are shown.

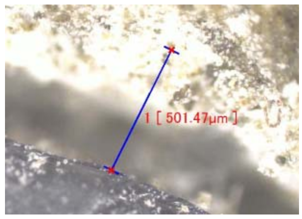
(a)Cutting surface



(b)Magnified view of gap

Fig.7 Cutting surface of expansive mortar with spherical marbles

(a)Cutting surface



(b)Magnified view at a edge

Fig.8 Cutting surface of expansive mortar with flat marbles

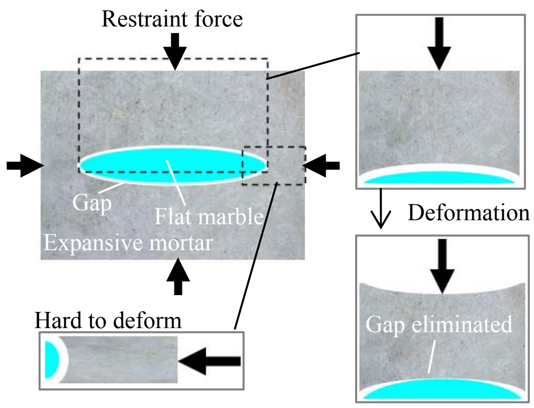
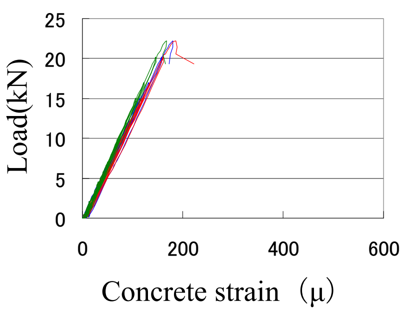
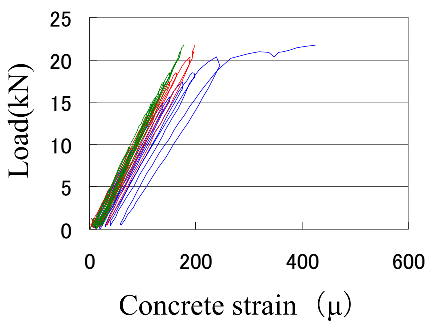


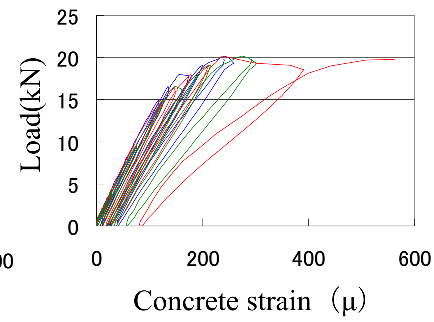
Fig.9 Mechanism of debonding on flat marble



(a)N (Crushed)



(b)E (Crushed)



(c)E (Marble)

Fig.10 Load-strain curves in repetitive bending test

The specimens are 400mm in length, 100mm in width and height, and axially restrained by a rebar of 16mm in diameter. The mix is shown in Table 3. Molds were removed 24 hours after casting and wet cloth was put on the specimen, and the test was conducted at the age of 10 days. Concrete strain of each specimen was measured with three strain gages which cover the whole uniform bending moment zone. The load was increased until cracking occurred.

The measured load-concrete strain curves are shown in Fig.10. Stiffness reduction and plastic deformation occur in expansive concrete and such nonlinear behavior is the most remarkable in the expansive concrete with marble gravel. In Fig.11, measured strain with strain gages where macro crack didn't cross is shown. It can be confirmed that in expansive concrete with marble gravel, nonlinear behavior occurred in the whole uniform bending moment zone. On the marble gravel, because of its shape, debonding occurred easily before the localization of damage. After the test, the specimen was cut and we confirmed some debonding on spherical marble but not in other specimens as shown in Fig. 12. The above discussion indicates that nonlinear behavior independent of material age occurred due to debonding on gravel surface.

3.2.4 Performance of concrete specimen after drying

Concrete specimens of 400mm in length and 100mm in width and height were prepared. The mix is shown in Table 3. All specimens were demoled 24hours after casting and cured under water without restrain until the age of 28 days, and after that, some specimens were kept under water, but the others in air. Fig.13 shows the cutting surface of the specimens at the age of four months and these pictures were taken after wetting the surface. As seen, the color around gravel got dark in expansive

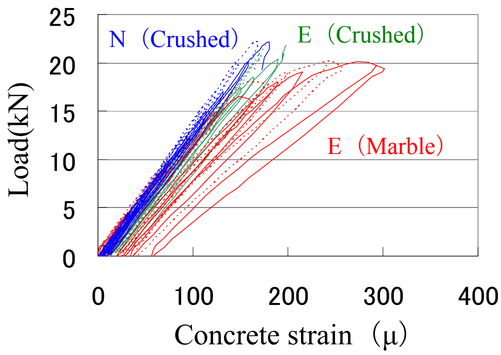


Fig.11 Load-strain curves in repetitive bending test


(a)E（Crushed）

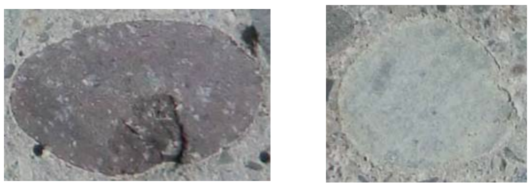

(b)E（Marble）

Fig.12 Gravel appeared on cutting surface

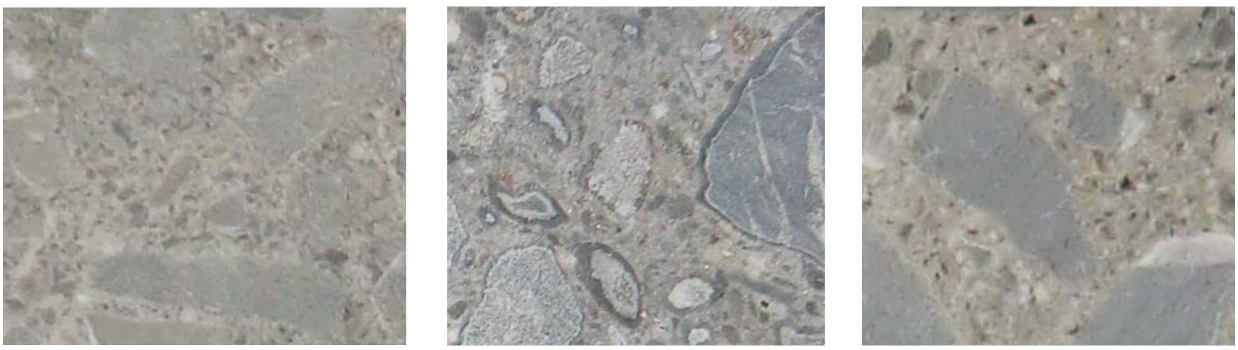

(a)N（cured under water）　(b)E（cured under water）　(c)E（dried）

Fig.13 Cutting surface of no-restraint specimens

Table 5 Mix proportion of paste

	W/B	Unit content(kg/m^3)		
	(%)	W	C	E（Rep. ratio）
N	40	557	1383	0
E1	40	557	1279	104（7.5%）
E2	40	557	1176	207（15%）

Fig.15 Air bubbles from the base of rebar

(a)N 28.4kN

(b)E1 32.6kN

(c)E2 Rebar fracture before cracking （breaking load 37.7kN）

Fig.14 Appearance of specimens when cracking occur

concrete cured under water for four months since water was kept in the micro debonding on gravel surface. On the other hand, when cured in air for three months, color around gravel didn't change. It is probable that this is because the micro debonding was disappeared by drying shrinkage. Flexural strengths of these specimens were measured and expansive concrete cured under water for four months showed 2.51 MPa, however, 3.08MPa in the specimen dried for three months. Although normal concrete also showed strength increase by drying (2.44 MPa to 2.54MPa), the difference was very small compared with expansive concrete. It is likely that the relatively large increase of flexural strength in dried expansive concrete is because of the elimination of the debonding and this might be the reason of the unique behavior reported by Tsuji, recovery of flexural cracking moment in CPC due to drying.

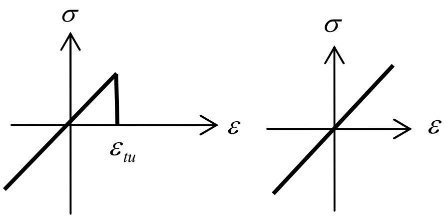
3.3 Bonding property

3.3.1 Uniaxial tension test using cement paste

In this section, the effect of expansive action on rebar is discussed. First, uniaxial tensile test was conducted using reinforced cement paste specimen of 160mm in length, 50mm in width and 70mm in height. The mix is shown in Table 5. The molds were removed 24 hours after casting and cured under water until loading at the age of 7 days. The appearance of specimens when cracking occurred are shown in Fig.14 and values in the figure are the cracking loads. As the volume of expansive additive increases, cracking load is increased, however, the value of (c) in Fig.14 indicates the load at the fracture of rebar which occurred before cracking when 15% of cement was replaced by expansive additive. The above results indicate that by expansive action, debonding on rebar surface occurred, similar to gravel seen in the previous section. The conjecture is supported by the fact that when expansive paste specimens were cured under water, air bubbles appeared from the base of the rebar as shown in Fig.15.

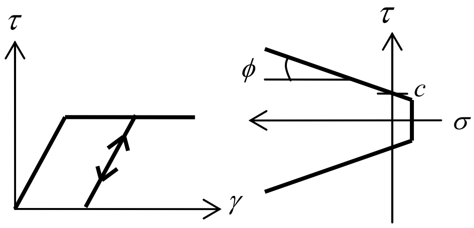
3.3.2 Effect of gravel to the debonding on rebar

In the previous item, it is confirmed that debonding occur on the rebar in expansive cement paste, however, according to the past researches, bond property of expansive concrete is similar to or better than that of normal concrete. A possible reason of the above discrepancy is the existence of gravel. In this item, the effect of gravel to the debonding is



(a)Mortar element (b)Rebar/gravel element

Fig.16 Constitutive low for normal spring



(a)Constitutive low (b)Yield criterion

Fig.17 Constitutive low for shear spring

examined numerically using Rigid Body Spring Model (RBSM). The framework for the simulation was prepared by modifying programs developed by Nagai et al.

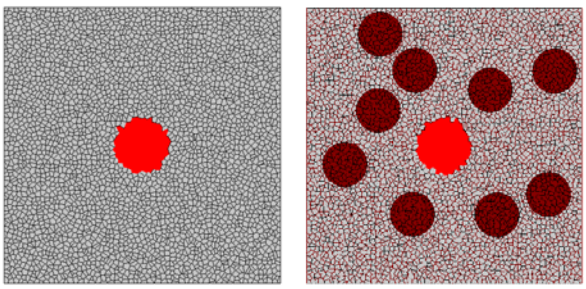
In the simulation, mortar, gravel and rebar elements are used and normal and shear sprigs are set among them. The constitutive low of the normal springs are shown in Fig.16. (a) is the low for mortar elements, elastic behavior in compression, and in tension, the stress become 0 when the strain reaches fracture strain. Perfect elasticity is given to gravel and rebar elements as shown in (b). Elastic plastic behavior is given to shear springs and the yield value is determined by the Mohr-Coulomb criterion. The constitutive low and yield criterion are shown in Fig.17 (a) and (b). Input constants for the simulation are shown in Table 6. Volumetric expansion is given to all mortar elements by 100μ per computational step and the expansion rate doesn't correspond to actual expansion behavior.

Two-dimensional analytical model with 100mm in width and height is used in the simulation. Analytical models are shown in Fig. 18. In the first case, a rebar element is put at the center of the mortar elements and, in the other case, gravel elements are put around the rebar. The four sides are not fixed so that expansion takes place freely. The shape of the rebar element is not smooth because of the algorithm of the mesh generation.

Fig. 19 and Fig. 20 are the obtained stress distribution at step 3 and step 5. Red indicates compressive stress and blue tensile stress and their brightness shows the magnitude. Damage, i.e.,

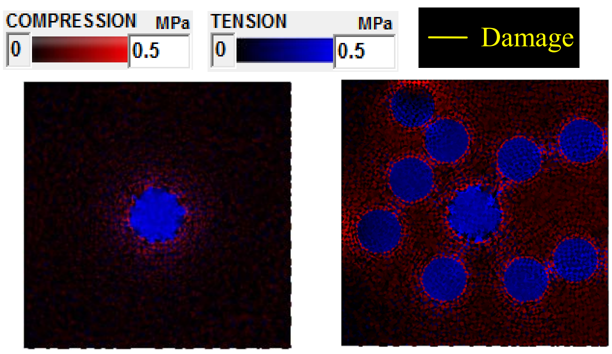
Table 6 Input constants

Mortar element	
Elastic modulus	30,000MPa
Fracture strain ε_{tu}	0.0002
Shear yield criterion	
Cohesion C	3.0MPa
Frictional angle φ	35°
Rebar/ gravel element	
Elastic modulus E_s	200,000MPa



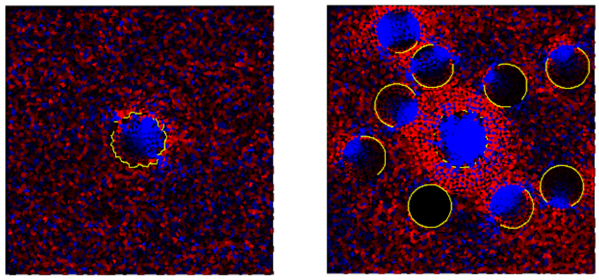
(a)Only rebar (b)Rebar & gravel

Fig.18 Analytical model



(a)Only rebar (b)Rebar & gravel

Fig.19 Stress distribution (before debonding)



(a)Only rebar (b)Rebar & gravel

Fig.20 Stress distribution (after debonding)

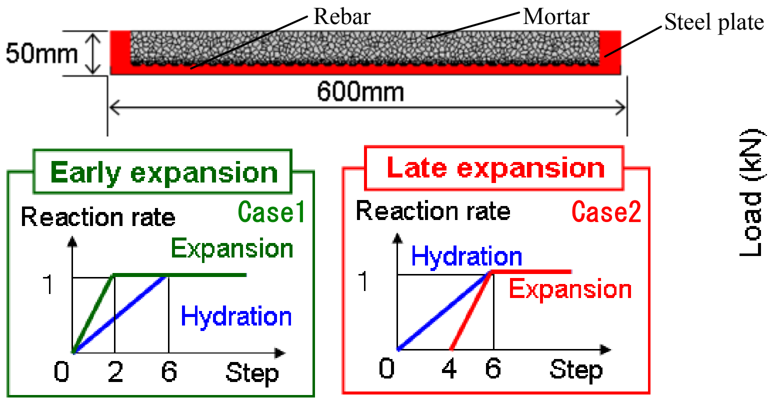


Fig.21 Analytical model and condition

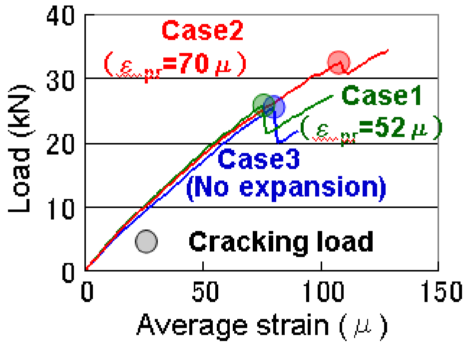


Fig.22 Results of simulation

debonding is shown in yellow lines. Fig. 19 is the result before debonding occurs. Tensile stress is introduced to rebar and gravel elements due to expansive action, conversely, compressive stress is introduced around them. In Fig. 20, in the model without gravel, debonding occurs around the rebar element, however, it is reduced in the model with gravel. The reduction is caused by gravel, which has the same size order with the rebar, disturbing uniform expansion around rebar, and also, restraining expansion. It can be seen that the debonding is more clear on gravel than that on rebar, this is because, the shape of the gravel is more close to circle. According to the simulated results, in real expansive concrete member, it is possible that the debonding on rebar is reduced because of gravel. In the past, Sahamitmongkol et al. conducted uniaxial tension test on concrete specimen with two times larger amount of expansive additive than recommended and no restrain around the rebar, however, there was no large decrease in bonding stress. On the other hand, in Murata's experiment, round bar was used and the bond stress decreased in expansive concrete when no restrain is given around rebar. The above results shows that debonding on rebar due to expansion is reduced by gravel and even if debonding occur, when deformed bar is used, the bonding stress doesn't decrease due to the ribs. In other words, enough restraint should be given when expansive mortar, paste or round rebar is used or the bond will be deteriorated.

3.3.3 Improvement of performance due to prestress and prestrain

Another numerical simulation with RBSM is conducted to examine the relationship between expansive action and performance of CPC. The constitutive low in this simulation is same with the one in the previous item. In the simulation, uniaxial tension behavior is examined and hydration and expansion process is considered; hydration is expressed by increasing the number of springs between elements and expansion by enlargement of elements. The above process is considered in six computational steps before the loading and during this process, one spring is added and extension of 30μm is given every step and each spring has sixth part of the elastic modulus in Table 6. The analytical model is shown in Fig. 21, 300mm in length and 30 mm in height. The mesh is generated by Voronoi diagram and axial symmetry is assumed. Average element diameter is around 1.5mm and the diameter of the rebar is 5mm and steel plates with 15mm in thickness are put at the both ends. In the simulation, in order to express uniaxial tension test on a cylindrical specimen, the distance from the bottom of the specimen to each element is multiplied to their elastic modulus, following Muto et al.'s report. In this simulation, three kinds of cases are examined. In early expansion case (Case1), expansion is given between 1st step and 2nd step and in late expansion case (Case2), between 4th and 6th, and no expansion in Case3. By the expansion, prestrain of 52μ and 70μ are introduced to the rebars in Case1 and Case2, respectively. Calculated load-strain curves are shown in Fig. 22. As seen, the cracking load in Case2 is higher than the other cases, however, that in Case1 is almost same with Case3, no-expansion case. This is because, in Case1, expansion took place when hydration was not enough, in other words, few springs were generated and only they got compressed. However, because of the prestrain, the strain of rebar is reduced and the stiffness is higher than Case3 apparently. Although the above simulation is simple, the effect of prestress and prestrain to the performance is clearly shown. First, prestress is compressive stress introduced to concrete and is calculated from prestrain, rebar strain introduced by expansion and, because of the prestress, the cracking stress increases. However, the prestress calculated from prestrain is not equal to the increment of cracking stress as seen in the simulation. It is confirmed experimentally also, for example, Ide et al. reported that the increment was only 30% of the calculated prestress. According to the simulated results, the fraction will change depending on the timing of expansion, i.e., the temperature or cement type etc. Because of prestrain, rebar strain and crack width are reduced and apparent stiffness increases. In other words, it's difficult to reduce crack width with expansive additive if the reinforcement ratio of the member is high. The above discussion indicates the importance to use expansive additive considering the capability between the purpose and the condition of concrete members.

4 CONCLUSIONS

In this paper, in order to understand the property of expansive concrete, the mechanisms of its unique behaviors are examined. Summaries are as follows;

1. Expansive action due to expansive additive causes strain variation in cement paste resulting in micro cracks and, under deformation, micro cracks are generated
2. The number and the size of micro cracks become less and smaller by aging or giving restraint.
3. Even under relatively strong restraint, tensile strain is introduced to gravel by expansion. Depending on the volume of expansive additive, restraint and gravel shape, debonding on gravel occurs.
4. Nonlinear behavior seems to be composed of two factors, affected and not affected by material age, and it is probable that they are micro cracks in cement paste and debonding on gravel, respectively.
5. Debonding on gravel due to expansion disappeared by drying and, in that case, in this paper, the bending strength increased by 20%.
6. Improvement of performance of CPC after drying seems to occur by the elimination of debonding on gravel.
7. By expansion, debonding on rebar also occurs, however, it is reduced by the existence of gravel.
8. When expansive mortar or paste, or round bar is used, it is necessary to be aware of deterioration of the bond.
9. Expansive additive should be used considering the purpose and the condition of the concrete members to make the most use of it.

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