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Strength of Fine Concrete Used in Textile Reinforced Concrete by Changing Water-Binder Ratio

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Abstract**—**Recently, the abnormal climate phenomenon has enlarged due to the global warming. As a result, temperature variation is increasing and the term is being prolonged, frequency of high and low temperature is increasing by heat wave and severe cold. Especially for reinforced concrete structure, the corrosion of reinforcement has occurred by concrete crack due to temperature change and the durability of the structure that has decreased by concrete crack. Accordingly, the textile reinforced concrete (TRC) which does not corrode due to using textile is getting the interest and the investigation of TRC is proceeding. The study of TRC structure behavior has proceeded, but the characteristic study of the concrete used in TRC is insufficient. Therefore, characteristic of the concrete by changing mixing ratio is studied in this paper. As a result, mixing ratio with different water-binder ratio has influenced to the strength of concrete. Also, as the water-binder ratio has decreased, strength of concrete has increased.

Keywords**—**Concrete, mixing ratio, textile, TRC

I. Introduction

REINFORCED concrete which is complementary to tension and compression is composite material being used to construction industry according to its structural, materially, durable advantage. However, as the technology developed, reinforced concrete structures have been enlarged, high-rised, and exposed to various environment such as extreme weather. Consequently, self-load of structure increased, crack occurred by external force, and steel is exposed to the air. Therefore, damage of concrete surface and corrosion of the steel is occurred and lead to reduced durability and safety. These phenomena are developed to great loss for maintenance. To solve this problem, the study about TRC which is perfectly substituted steel by textile is in motion recently. During the last 10 years, the scientific community's growing interest in the textile technology has been demonstrated by the establishment of several research projects, the majority in Germany, Israel, USA and the Italy [1]. Textile is made up as bundle of carbon, glass, aramid filament. As steel is substituted by textile, general mixing ratio used for reinforced concrete cannot be used, and fine-grained aggregate is used which is the diameter is under 0.6mm. So, the research for concrete using fine-grained concrete was performed by various researchers.

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The research about effect of fine aggregate on concrete strength is studied by changing amount of fine aggregates and size of aggregate. This study shows that when the positive effects of fine fillers are clearest in mixtures and what is the positive effect of fine aggregates [2]. The best type of fine aggregate is figured out by changing different type of fine aggregate. High-strength concrete having similar or better mechanical strength than concrete with natural sand can be produced using crushed sand as fine aggregate. Crushed sands require a higher dosage of admixture to overcome the adverse shape and texture of particles [3]. Hochschule Rheinmain University performed the test for concrete which is used in TRC. The compressive test has been performed using small sized specimens of varying geometry and side lengths. This study figured out compressive strength is depending on the specimens' geometry [4]. Dalian University of Technology studied TRC, and fracture characteristics of fine grained concrete used in TRC. The test show that there also exists a steady crack propagation stage before unstable fracture of fine grained concrete during its fracture of fine grained concrete during its fracture process, and the unstable fracture toughness does not change, but with the increase of beam depth, the initial fracture toughness decreases. [5]. However, as to the research due to the present, concrete used in TRC is studied in many countries, but concrete have different characteristics according to its aggregate region. So in this research, compressive strength test of concrete made with aggregate in South Korea was performed. By this experiment, it could be easier to apply TRC to construction industry of South Korea.

II. TRC

TRC is Textile Reinforced Concrete where multi-axial fabric substitute for reinforcement are used in combination with fine grained concrete. This allows the design of very thin-structured concrete elements with a high strength in compression as well as in tension. TRC is economical structure because of it could prevent decrease of durability according to the characteristic of anti-corrosive. It is easily manufactured in various shapes due to the shaping is freely. Also, TRC has excellent ductility and crack resistance and by using textile and concrete, covering depth could be decreased. As covering depth is decreased, amount of CO_2 emission is decreased according to decrease of amount of concrete used. TRC is shown in Fig. 1.

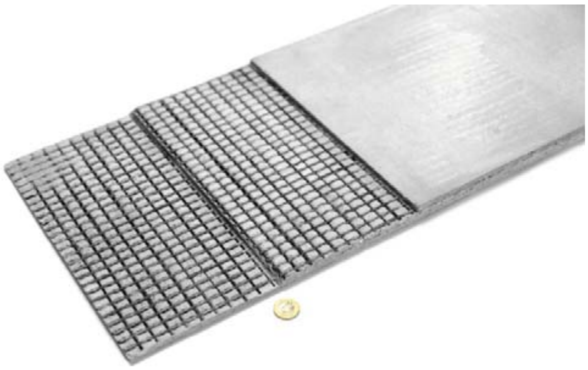

Fig. 1 TRC

A. Textile

Textile is grid shaped weaving fabric which is formed as fishnet with warp (longitudinal fiber) and weft (horizontal fiber) as shown in Fig. 2. Each warp and weft is composed of yarns. Yarn is generic term for a continuous strand of textile fibers, filaments of material in a form suitable for knitting, weaving or otherwise intertwining to a form of textile fabric. One yarn consists of hundreds up to thousands of single filaments. Filament is a fiber of an indefinite or extreme length such as found naturally in silk. Filament is basic components of textile.

Textile properties can be classified to 3 types as glass fiber, carbon fiber, and aramid fiber. Each fiber has different properties such as toughness and modulus of elasticity. From among these, as AR-glass (Alkali Resistant Glass) which is a kind of glass fibers has good adhesion with concrete and good cost-effectiveness; it is used typically to TRC. The reason why using AR-glass is according to TRC is used with concrete, fiber should have property of alkali resistance. AR-glass contains zircon over than 15%. Table I is properties of AR-glass.

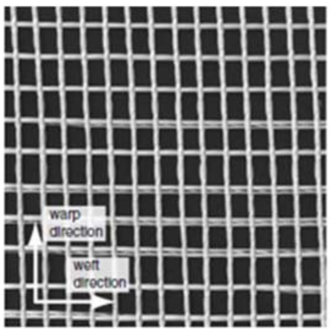

Fig. 2 Warp and weft direction

TABLE 1
PROPERTY OF AR-GLASS

Diameter (μm)	Density (kg/dm^3)	Tensile Strength (MPa)	Modulus of Elasticity (GPa)
27	2.8	1400	70-80

B. Concrete

According to using textile substitute for reinforcement, original mixing ratio which is consists of large aggregate cannot be used due to adhesion between textile and concrete. Therefore, fine aggregate that diameter is under 6 mm is used when mixing TRC concrete similar to powder concrete. It is concrete, but close to mortar. According to using the fine aggregate, sufficient amount of water is needed and it is essential to secure the liquidity by the addition of superplasticizer. Silica fume and fly-ash is added for strength and durability.

III. Experiment

Experiment has proceeded in 4 case of different concrete mixing ratio. The test specimen shall be cylinder the diameter of 10 cm and height of 20 cm. Specimen 2, specimen 3, specimen 4 have same amount of aggregate but different amount of water. The difference of the specimen 1 and the specimen 3 is that silica fume is included or not. The fine aggregate is used with no.6 sized sand (0.25~0.6 mm) and no.7 sized sand (0.1~0.25 mm). Table II shows the detailed mixing ratio.

TABLE II
CONCRETE MIXING RATIO OF 8L

Specimen	W/B ratio	Unit weight (kg)						
		Water	Cement	Fly-ash	Silica fume	No.6 sand	No.7 sand	SP
S1	0.40	2.24	3.92	1.40	0	4.00	5.71	0.056
S2	0.45	2.52	3.92	1.40	0.28	4.00	5.71	0.056
S3	0.40	2.24	3.92	1.40	0.28	4.00	5.71	0.056
S4	0.35	1.96	3.92	1.40	0.28	4.00	5.71	0.056

The experiment has proceeded by using UTM-2000 which is shown in Fig. 3. The test has done with age of 7 days and 28 days concrete specimens.

Fig. 3 Experimenting by UTM-2000

The mixing procedure shall be as Fig. 4. The mixing procedure followed KS L ISO 679 and ISO 679 [6]. The test in this paper was concrete compressive strength test, but as the concrete formed with fine aggregate, we followed mortar mixing procedure.

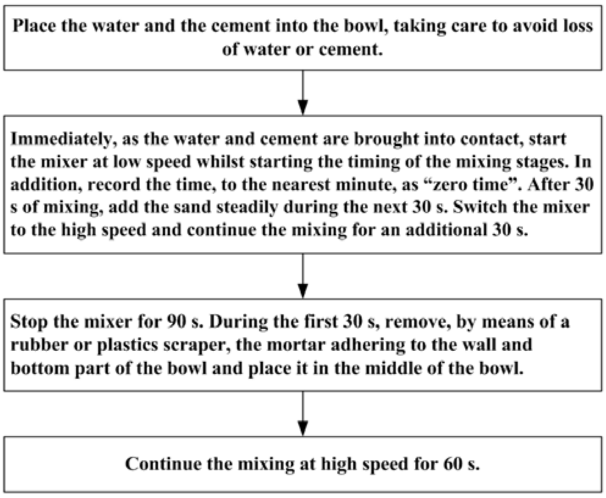

Fig. 4 Mixing procedure

In Fig. 4, "Zero time" is the point from which the times for demoulding specimens and for determining strength are calculated.

IV. Result

As a result, specimen S1's 7 days compressive strength was 18.142 MPa, and 28 days compressive strength was 27.547 MPa. The compressive strength of S1 is the lowest of other specimens. The reason is because S1 is not included silica fume, the strength decreased. Specimen S2's 7 days compressive strength was 25.387 MPa, and 28 days compressive strength was 47.553. Specimen S3's 7 days compressive strength was 30.473 MPa, 28 days compressive strength was 44.137 MPa. Specimen S4's 7 days compressive strength was 33.609 MPa, 28 days compressive strength was 45.046 MPa. The test result is shown in Table III.

As the result of experiment, compressive strength of S1 which does not includes silica fume was the lowest. On characteristic of the concrete, as the water-binder ratio lowers the compressive strength of concrete rises. However, the 28 days compressive strength of S2 was the highest even though water-binder of S2 was the highest. Mostly, the tendency that the compressive strength of concrete rose as water-binder ratio became low was seen. The concrete fracture aspect occurred similarly altogether like Figs. 5 and 6.

TABLE III
Compressive Strength of Concrete

Specimen	Compressive Strength(MPa)	
	7 days	28 days
S1	18.142	27.547
S2	25.387	47.553
S3	30.473	44.137
S4	33.609	45.046

Fig. 5 Fracture aspect of 7 days compressive strength

Fig. 6 Fracture aspect of 28 days compressive strength

V. Conclusion

In this paper, the compressive strength of concrete was measured with different water-binder ratio using fine aggregate.

1) By experiment, as the water-binder ratio has decreased, the compressive strength of concrete has increased mostly and the compressive strength has plunged when silica fume does not include. As the amount of strength increase was small, it appeared that the effect of water-binder ratio is slight.
2) According to the fine aggregate absorbs the much water, we determined the compressive strength of 7 days appeared regularly for enough amount of water, but the amount of water till 28 days was not sufficient and of which the compressive strength was not appeared regularly. Also, the test proceeded in midwinter, the compressive strength have fallen by curing problem. The further detail study will be needed curing with appropriate temperature.

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