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DEVELOPMENT OF MULTI-LAYERED SEWER PIPE PLUG -3RD REPORT: TENSILE STRENGTH OF PROTECTIVE SHEET BONDED BY ADHESIVE

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Since the sewer system in Japan is becoming obsolete, it is, therefore, necessary to reinforce or repair without stopping sewer functions by applying a suitable water stopping method. In this study, a multi-layered sewer pipe plug consisting of the protective sheet and two rubber balls is focused since it can be installed and removed at the construction site in a short time conveniently. Four types of adhesively bonded structures are investigated experimentally by changing bonding processes and adhesives. It is found that the main and base adhesive joint is the most suitable since the pressurized adhesive strength $\sigma_B = 60$MPa is 30% of the standard tensile strength of the protective sheet $\sigma_{B0} = 200$MPa.

Keywords: Sewer Pipe Plug; Protective Sheet; UHMWPE fiber; Bonded Method

1. Introduction

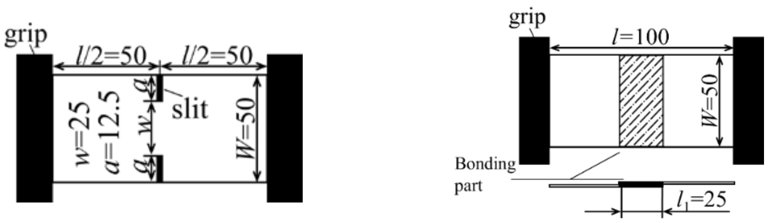
In Japan, a lot of sewer systems are becoming obsolete should be repaired. Traditional one-layer pipe plugs cannot be used without the risk of rupture. To update and repair the sewer system safely and efficiently, a three-layer pipe plug reinforced by the protective sheet should be developed. The previous rapture test showed that the fracture originates at the seemed portion of the protective sheet near the inner corner of the flange.[1-5] The previous tensile test showed that the seamed tensile strength σ_B is σ_B =34MPa, which is about 17% of the standard tensile strength σ_{B0} =200 MPa. Therefore, in this paper, adhesively bonded ultra-high molecular weight polyethylene fibers (UHMWPE) will be newly focused. A tensile test will be conducted to clarify the strength due to the difference in the adhesive bonding method.

2. Tensile test of the protective sheet made by ultra-high molecular weight polyethylene fibers (UHMWPE) bonded by adhesive

Tensile tests will be conducted to clarify the strength of the adhesive part. Shimadzu universal testing machine AGS-J 10kN is used as the tensile testing machine. Japan

Industrial Standards L 1096 prescribes testing methods for woven and knitted fabrics stating that the size of the specimen length l =200mm, width W =50mm. In this study, $l = 100\text{mm}, W = 50\text{mm}$ are used. The tensile speed of the test is 100mm/ min as prescribed in JIS L 1096. Fig. 1 (a) shows tensile specimens without adhesive. The slit of the specimen not prescribed in JIS is considered in Fig. 1 (a) to prevent the fracture at the griped portion. The specimens with slits have the minimum section width *w*=25mm with 1mm thickness. The griped portions at both ends of the test piece are reinforced by the adhesive and fixed with gum tape. Fig. 1 (b) shows tensile specimens with adhesive whose overlap length l_1 =25mm is bonded at the center of the specimen.

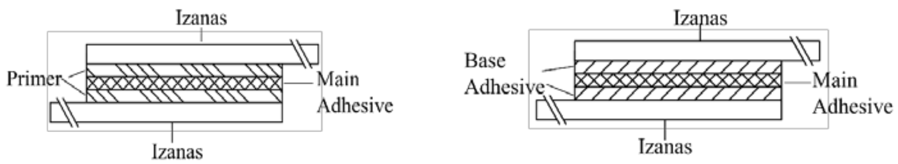
Fig. 2 illustrates 4 adhesive joints. In Fig. 2 (a), the primer is applied by using a brush, then the main adhesive is applied by using a spatula and then joined without pressurization. In Fig. 2 (b), the base adhesive is applied by using a spatula, then the main adhesive is applied by using a spatula and then joined without pressurized. In Fig. 2 (c), (d) the pressurized adhesive joints are considered. In Fig. 2 (c), the base adhesive is applied by using a spatula, then the main adhesive is applied by using a spatula and then joined. In Fig. 2 (d), only the main adhesive is applied by using a spatula and then joined. After joining, the adhesive portion is hit with a hummer and pressurized at a weight of 5.0kgf for 12 hours.



(a) Tensile specimen without adhesive

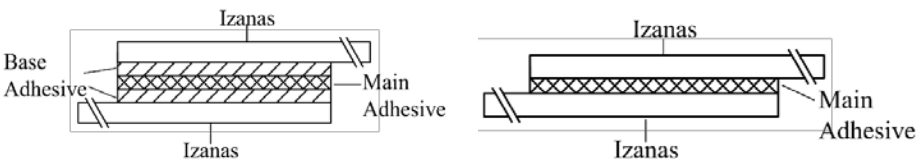
(b) Tensile specimen with adhesive whose overlapped length $l_1 = 25\text{mm}$

Fig. 1. Tensile specimen



(a) Main adhesive and primer joint without pressurized

(b) Main and base adhesive joint without pressurized



(c) Main and base adhesive joint with pressurized

(d) Main adhesive only joint with pressurized

Fig. 2. Illustration of 4 adhesive joints in Fig.1(b)

3. Unpressurized adhesive strength

Table 1 summarizes the unpressurized adhesive tensile strength obtained for the specimens in Fig. 2 (a), (b). The tensile strength σ_B in Table 1 is defined by the maximum tensile force P divided by the cross-sectional area $A = wt$. In Table 1, the average tensile strength in Fig. 1 (a) is defined as the standard tensile strength σ_{B0}. From Table 1, it is seen that the maximum unpressurized adhesive strength σ_B =28MPa in Fig. 2 (b) is 14% of the standard tensile strength σ_{B0} =200MPa in Fig. 1 (a). The observation shows that the adhesive does not enter the gap between the threads for the unpressurized tensile specimen.

Table. 1. Unpressurized adhesive tensile strength of UHMWPE cloth

Specimen	Adhesive structure	Minimum width w	Tensile strength σ_B [MPa]	σ_B/σ_{B0}	Pressurized or unpressurized
Fig. 1 (a)	——	25	$\sigma_{B0} = 200$	100%	——
Fig. 2 (a)	Main + Primer	50	7	4%	Unpressurized
Fig. 2 (b)	Main + Base	50	28	14%	Unpressurized

*σ_B is tensile strength. σ_{B0} is standard tensile strength in Fig. 1 (a).

4. Pressurized adhesive strength

Fig. 3 shows the stress-strain diagram for the specimen with pressurized adhesive in Fig. 2 (c), (d) compared to the specimen without adhesive in Fig. 1 (a). Table 2 summarizes the adhesive tensile strength obtained for the unpressurized adhesive specimens and pressurized adhesive specimens in Fig. 2. From Table 2, it is seen that the pressurized adhesive strength σ_B =60MPa in Fig. 2 (c) is 30% of the σ_{B0} =200MPa in Fig. 1 (a) better than the pressurized adhesive strength σ_B =40MPa in Fig. 2 (d).

From Table 2, it is seen that the pressurized adhesive strength σ_B =60MPa in Fig. 2 (c) is twice the unpressurized adhesive strength σ_B =28MPa in Fig. 2 (b). It can be concluded that the tensile strength can be improved by pressurized adhesive bonding.

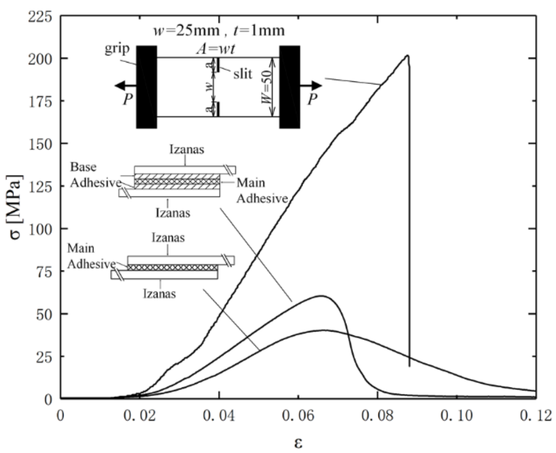


Fig. 3. Stress-strain curve for the pressurized adhesive specimen in Fig. 2 (c), (d) in comparison with the specimen in Fig. 1(a)

Table. 2. Adhesive tensile strength of UHMWPE cloth

Specimen	Adhesive structure	Minimum width w	Tensile strength σ_B [MPa]	σ_B/σ_{B0}	Pressurized or unpressurized
Fig. 1 (a)	——	25	$\sigma_{B0} = 200$	100%	——
Fig. 2 (a)	Main + Primer	50	7	4%	Unpressurized
Fig. 2 (b)	Main + Base	50	28	14%	Unpressurized
Fig. 2 (c)	Main + Base	50	60	30%	Pressurized
Fig. 2 (d)	Main only	50	40	20%	Pressurized

*σ_B is tensile strength. σ_{B0} is standard tensile strength in Fig. 1 (a).

5. Conclusions

In this study, the tensile test is conducted to investigate the adhesive strength of the protective sheet made by ultra-high molecular weight polyethylene (UHMWPE) cloth named Izanas cloth. The conclusions can be summarized in the following way.

(1) A tensile test is conducted to investigate the unpressurized adhesive tensile strength of UHMWPE cloth in Fig. 1(b). It is found that the unpressurized adhesive strength is σ_B =28MPa in Fig. 2 (b), which is about 14% of the tensile strength of Izanas cloth σ_{B0} =200MPa in Fig. 1 (a).

(2) A tensile test is conducted to investigate the pressurized adhesive tensile strength of UHMWPE cloth in Fig. 1(b). It is found that the pressurized adhesive strength is σ_B =60MPa in Fig. 2 (c), which is about 30% of the tensile strength of Izanas cloth σ_{B0} =200MPa in Fig. 1 (a).

(3) It is seen that the pressurized adhesive strength σ_B =60MPa in Fig. 2 (c) is twice the unpressurized adhesive strength σ_B =28MPa in Fig. 2 (b). It can be concluded that the tensile strength can be improved by pressurized adhesive bonding.

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