Junction properties interpretation of textile geogrids using multi-junction clamp

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ABSTRACT: In this paper, multi-junction clamp was used for junction strength evaluation under 20, 50 and 100 mm/min of strain rate at ambient condition. 1~8 rib specimens were gripped in the clamps and each gage length was 50mm, 100mm and 150mm, respectively. Warp knitted and woven type geogrids were used to compare the effects of multi-junction clamping on junction and tensile strength, respectively. When the strain rate was increased, junction strength of woven type increased, but there was no effect by strain rate on warp knitted type. Newly designed clamp test for geogrid junction strength in this research is more accurate than the single junction test, considering the scale effect of specimen.

1 INTRODUCTION

Geogrids imposed loads due to a friction of cross direction rib surface to soil and passive resistance of cross direction ribs are transferred through junction to mechanical direction rib. Therefore, sufficient junction strength is needed to carry the induced force (Hufenus, 2005). In general, junction efficiency and junction strength per unit width is calculated by a conversion equation that is recommended in GRI GG-2 (GRI, 2002). The GRI GG-2 test method has an inherent weakness in not being able to take into account the scale effect of geogrid specimens. Most of the geosynthetics being used for civil engineering are used as tensile members, and they are subject to an assessment of their tensile strength by taking a specimen of wide width (Koerner, 2005). Therefore, more reliable test methods, which include the scale effect is needed. And the current trend in the assessment of the tensile strength of geosynthetics is that tensile strength tests on a specimen with a width as wide as possible. This is a desirable attempt to provide more accurate and reliable test data, considering the scale effect of a specimen. In this study, the multi-junction test method was suggested for the assessment of the geogrids junction strength to consider the aperture size scale effect.

2 EXPERIMENTAL

2.1. Preparation of Geogrids

PET filament woven and warp knitted geogrids with PVC coating were used and the specification and physical properties of geogrids were represented in Table 1.

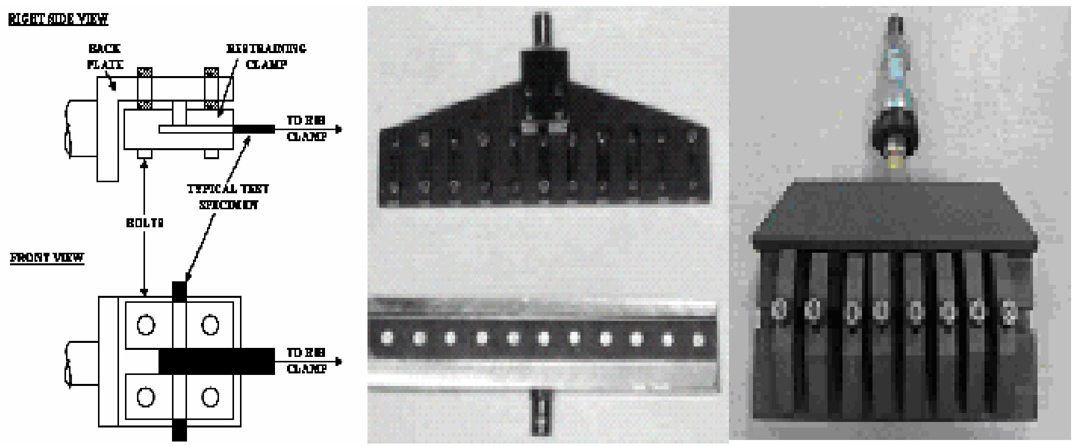
Table 1. Specifications of geogrids.

Geogrid	Raw Material /Coating Agent	Number of ribs (/m)	Mechanical properties			
			Ultimate Strength (ton/m)		Elongation at Break (%)	
			MD	CMD	MD	CMD
W-GG-1	PET/PVC	47	6	3	12	NA
W-GG-2	PET/PVC	38	10	3	12	NA
WK-GG-1	PET/PVC	42	6	3	12	NA
WK-GG-2	PET/PVC	38	10	3	12	NA

(MD is machine direction and CMD is cross machine direction, respectively)

2.2 Single and Multi Junction Tests

A testing apparatus as described in Figure 1 (a) is used mainly for the assessment of only one junction strength of a geogrid according to GRI GG-2. The test method uses a clamping fixture that grips the transverse ribs of the geogrid immediately adjacent to and on each side of the longitudinal rib. The lower portion of the longitudinal rib is gripped in a standard clamp, and each clamp is mounted in a tensile testing machine, where the test specimen is pulled apart. This method gives single-junction strength, junction efficiency and geogrids junction strength per unit width. The first values of single-junction strength are obtained directly from the test results. In previously research old designed multi-junction clamp was used to test geogrids junction strength (Figure 1 (b)). The basic concept for this equipment was to widen the single junction test clamp and the point-to-point length was determined by the aperture size of test conditions. For the old designed multi-junction test, a point-to-point length was 25 mm and the width of clamp was 280 mm. The upper clamp has 11 gripping points for junctions and the lower clamp is a kind of flat type which has also 11 gripping points (Jeon et al., 2000, 2003). Using this modified method of determination, the geogird junction strength should be more reasonable than single junction test.



(a) (b) (c)

Figure 1. Overview of junction test clamp (a) single junction test clamps (b) old designed multi-junction clamp (c) newly designed multi-junction clamp.

However, this kind of clamp is only suitable in testing the geogrids which aperture size was 25 mm. A newly developed multi-clamp was used to test junction strength recently. This is a composed drawing of multi-junction grip. The clamp is composed of a set of single grips in parallel. The clamp grips pitch can be freely adjusted. And the total number of the restraining grip is 11. In lower part, normal type rib clamp was used. Figure 1(c) shows the newly designed multi-junction clamps. In order to evaluate the effectiveness of the newly developed multi-junction testing apparatus and test condition (strain rate, specimen length and junction numbers), multi-junction clamp was used for junction strength with 20, 50 and 100 mm/min test speed at ambient condition. 1~8rib specimens were gripped in the clamps and the gage length was 50mm, 100mm and 150mm. Further more, single junction test samples were prepared according to GRI-GG 2 test method while test process was according to ASTM 4595 for united test condition. Multi-junction test has been used under the same testing conditions and procedure as ASTM 4595 except for the clamp devices.

2.3. Single and wide-width tensile tests

Single and wide-width tensile strength test conditions were utilized according to ASTM 4595 test method. Roll grip clamp was used in this test. Total test conditions are given in Table 2. The test data compared with those of junction tests.

Table 2. Description of test conditions.

Properties	Single junction test	Multi- junction test	Single tensile test	Wide-width tensile test
Scale effect	Unconsidered	considered	Unconsidered	Considered
Slip	Unconsidered	Unconsidered	Considered	Considered
Strain rate (mm/min)	70 (20, 50,100)	70 (20, 50, 100)	70	70
Specimen width	1 rib	1~8rib (200 mm)	1 rib	200 mm
Specimen length (mm)	300 (50, 100, 150)	300 (50, 100, 150)	300	300

3 *THEORETICAL BACKGROUND*

The experimental results were reported in terms of the multi-junction strength per specific number of ribs and the geogirds junction strength per unit width computed by the following equation.

$$J_{multi\text{-}rib} = \sum_{i=1}^{n} J_{i\text{-}multi}/n \qquad (1)$$

$$J_{grid} = \frac{(J_{multi\text{-}rib})(n_{junction})}{(W)(n_{test})} \qquad (2)$$

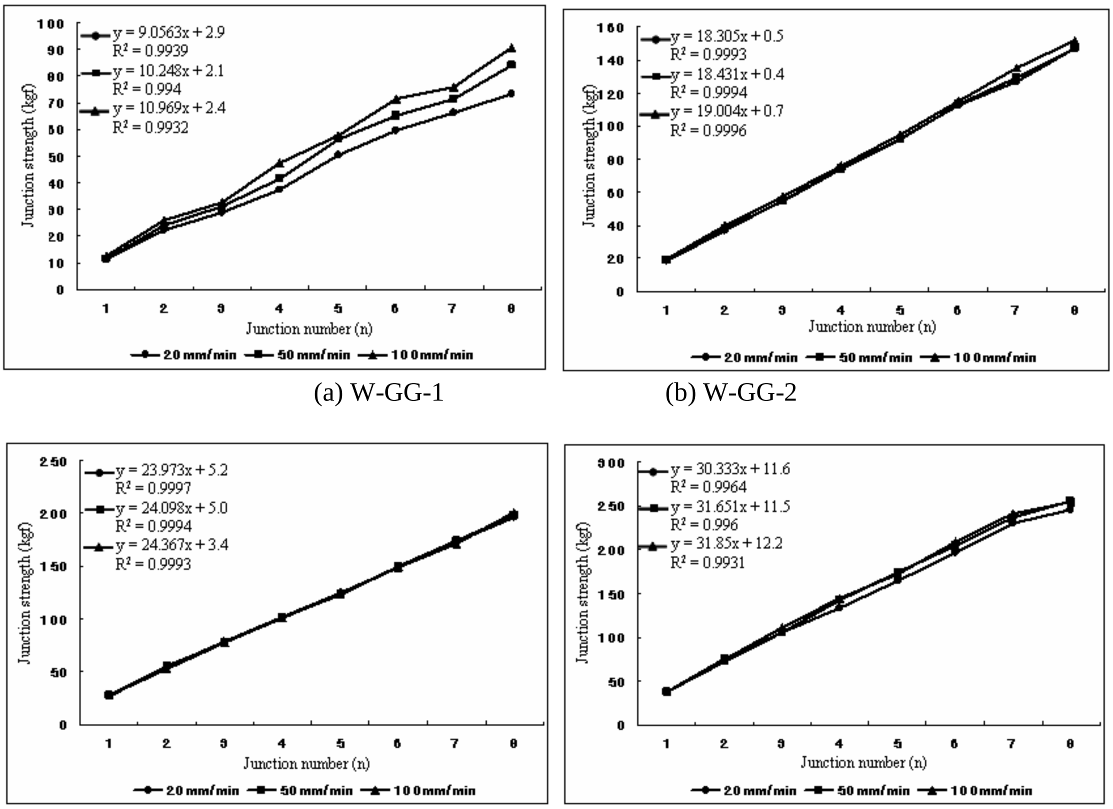
$$E_{junction} = \frac{J_{multi\text{-}rib}}{T_{wide\text{-}width}} \times 100 \qquad (3)$$

,where $J_{multi\text{-}rib}$=junction strength of a specimen width i number of junctions (average); $J_{i\text{-}multi}$=each junction's junction strength width i number of junctions (experimental value); n=total number of test specimens; J_{grid}=geogird junction strength per unit width; $n_{junction}$=number of geogird junction per unit width; W=unit width (typically 1m or 1 ft); n_{test}=number of junction in the tested specimen; T_{grid}=geogrid tensile strength per unit width.

4 RESULTS AND DISCUSSION

4.1. Optimization of Geogirds Multi-Junction Strength Evaluation

Average junction strength per one rib and the geogrids junction strength per unit width are also calculated by using multi-junction test results. Firstly, geogrids which have 1-8 junctions were tested and curves of junction strength to number of junction were plotted. Secondly, normalized values of junction strength were calculated for each sample. Figure 3 shows the results of regression analysis on the number of junctions versus junction strength with strain rate of geogrids. For woven type geogrids, all the plots were divided uniformly and the curves showed the same trend. Hence the data have a good reliability. Junction strength linear increased with the numbers of junction and fitting was excellent with R-squared value greater than 0.99. The difference is considered to be caused by scale effect and variation in the difference of manufactured product. For warp knitted geogrids, each normalized value is less than the value tested by single junction test because of scale effect. This figure illustrates that junction strength strongly depends on junction number. When the numbers of junction point are less than three (including three), the normalized junction strength of woven type decreases markedly. When the numbers of junction point ranged from four to eight (include eight), the normalized junction strength of woven type changed slightly.



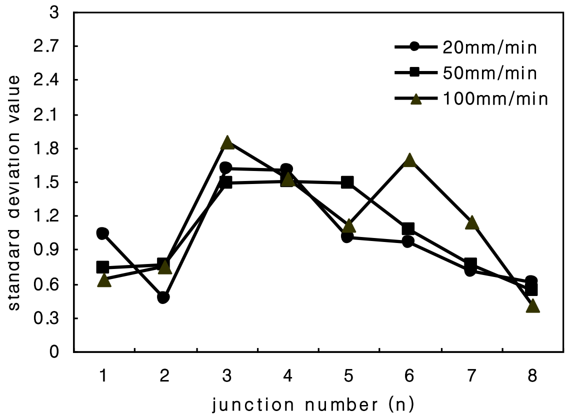
(a) W-GG-1 (b) W-GG-2

(c) WK-GG-1 (d) WK-GG-2

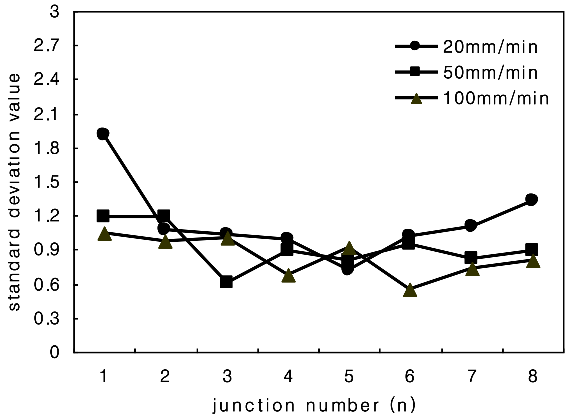
Figure 3. Regression analysis for the number of junctions versus junction strength with strain rate for geogrids.

Figure 4 shows the standard deviation data of normalized value plotted against junction number. The result indicated that the variable for a specimen with less than three junctions was irregularly caused by less of balance and no sufficiently considered scale-effect. When the junction number more then four (include four), the value of standard deviation decreased slightly. From this review, it is seen that the normalization of junction strength is more reasonable with increasing of junctions. Therefore, in order to consider the sufficient scale effect, the junction width should be as wide as possible. Considering various factors effecting on the results of junction strength and according to

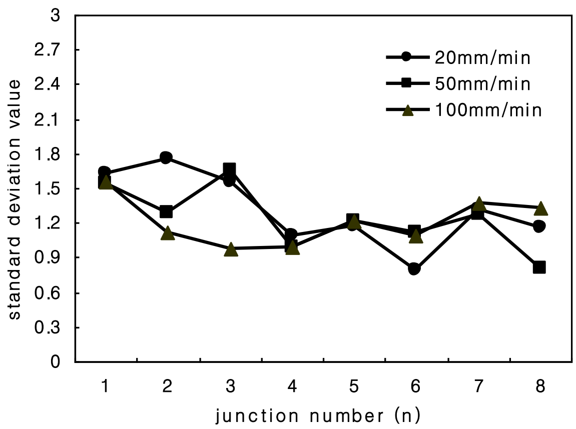
GRI-GG2 test method, multi-junction strength test proposed the entire width of a 200mm by at least 100mm length griping distance and setting the strain rate of 10±3%/min.



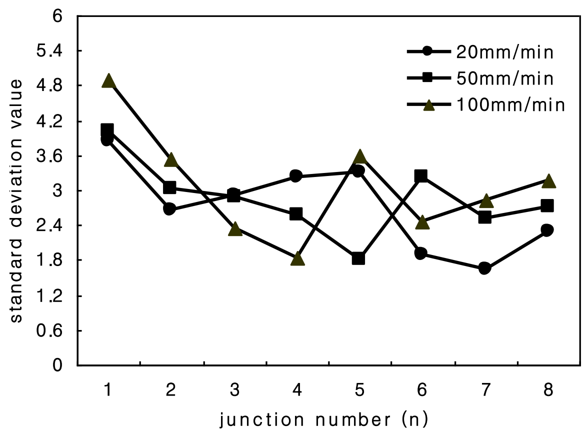
(a) W-GG-1



(b) W-GG-2



(c) WK-GG-1



(d) WK-GG-2

Figure 4. Standard deviation data of normalized value plotted against junction number.

4.2. Analysis of Tensile Property and Junction Property for Geogrids

Similar to tensile test, comparing the junction strength from single junction test with the multi-junction test, multi-junction test values are smaller than single-junction test values. This difference is due to the scale-effect and multi-junction test is more accurate than single-junction test. Scale-effect exists in both tensile and junction test. Figure 5 shows the difference between wide-width and junction-width tensile test. The value of tensile strength which uses the multi-junction clamp is markedly less than using roll clamp. The significant distance is due to slippage occurs during the multi-junction test.

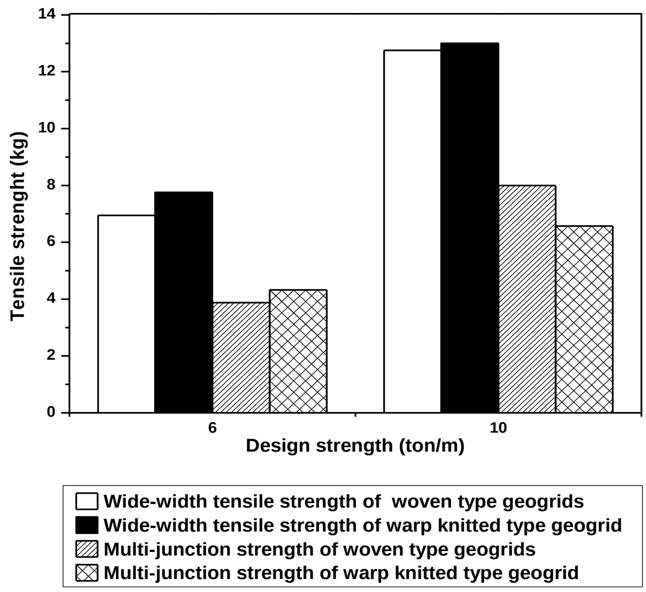


Figure 5. Tensile strength measured by wide-width and junction-width tensile test method.

5 CONCLUSION

The total trend of junction strength of geogrid decreased with the number of junction. When strain rate increased, geogirds of woven type junction strength increased, while there is no effect by strain rate on warp knitted type. The junction strength with junction numbers under different strain rate showed the same trend in both woven and warp knitted types. Specimen length do not effect on junction strength. Similar to tensile test, geogrid junction strength values from multi-junction test is lower than that from single junction test due to scale effect of specimen. Junction strength correction coefficient value is lower than tensile strength, especially warp knitted type which shows markedly decrease in junction strength. It is appropriate to evaluate the geogrids junction strength and junction efficiency by using the geogrids multi-junction test method considering scale effect. Considering various factors effecting on the results of junction strength and according to GRI-GG2, ASTM 4595 test method, multi-junction strength test proposed the entire width of a 200mm by at least 100mm length griping distance and setting the strain rate of 10±3%/min. More studies are needed to investigate in the relationship among these factors, cyclic load time, polymer raw material, maximum grain size, the gradation and the shape of the soil particles (rounded/angular).

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