

Fig. 2 Water absorption rate of sintered bricks with different percentages of LGSC added to clay loam

The compressive strength of the brick samples are shown in Fig. 3. When low grade silicon carbide (LGSC) is added during the brick sintering process, the compressive strength of the brick samples can be increased to a minor extent but the percentage of LGSC added does not have a visible effect on the compressive strength of the brick samples between 230-280 kgf/cm<sup>2</sup>. When the product is added with 5%, 15%, or 35% of the 4:1 silicon carbide to silicon LGSC group, the compressive strength of the product can reach a maximum of 260 kgf/cm<sup>2</sup>, while the compressive strength of the product added with 25% of the 3:1 silicon carbide to silicon LGSC can reach 280 kgf/cm<sup>2</sup>.

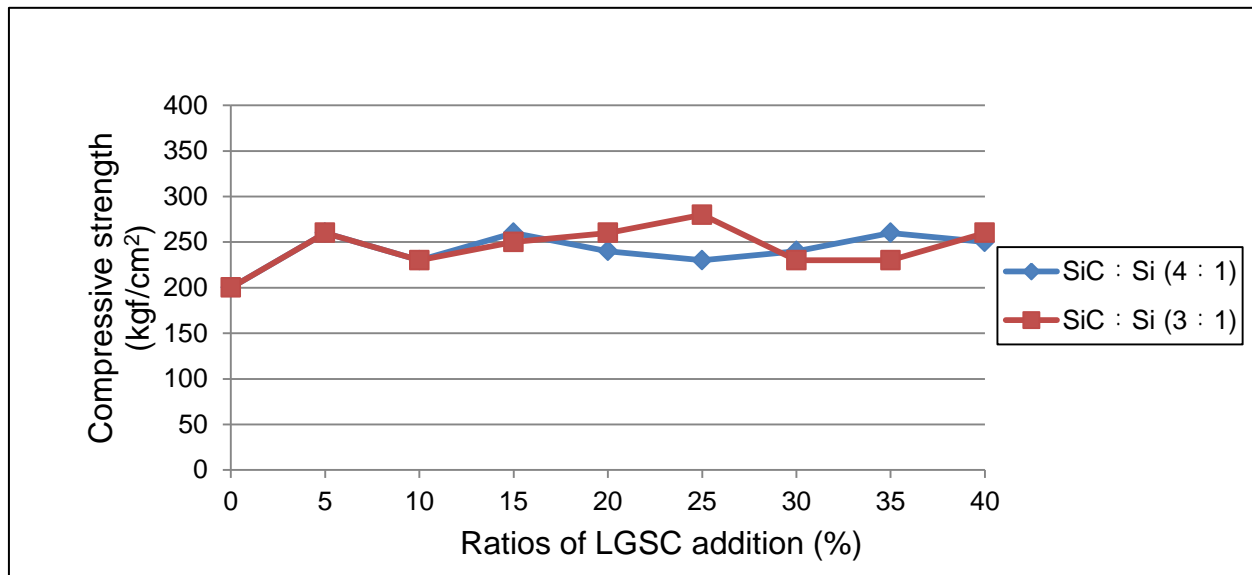


Fig. 3 Compressive strength of sintered bricks with different percentages of LGSC added to clay loam

After the silicon carbide and silicon are mixed at ratios of 4:1 and 3:1, the grade distribution chart of the bricks made from the addition of the mixtures to the clay loam are shown in Fig. 4 and Fig. 5, respectively. The red box shows the scope of standards for Class 1 bricks, with a water absorption rate below 10% and compressive strength above 300 kgf/cm<sup>2</sup>. The brick samples made with either groups of LGSC do not conform to the scope of criteria for Class 1. The green box shows the scope of standards for Class 2 bricks, with a water absorption rate below 13% and compressive strength above 200 kgf/cm<sup>2</sup>. For bricks manufactured with zero to 25% addition of either group of LGSC, the bricks can roughly meet the standards for Class 2 bricks. The purple box shows the scope of standards for Class 3 bricks, with a water absorption rate below 15% and compressive strength above 150 kgf/cm<sup>2</sup>. In general, with the exception of a few addition percentages, the bricks can meet the standards for Class 3 bricks. The results and data show that the mixture ratio of 4:1 and 3:1 of silicon carbide and silicon does not have an effect on the grade of the brick samples. Meanwhile, for the bricks to achieve Class 2 standards, the maximum percentage of added silicon carbide and silicon mixture is 25%.

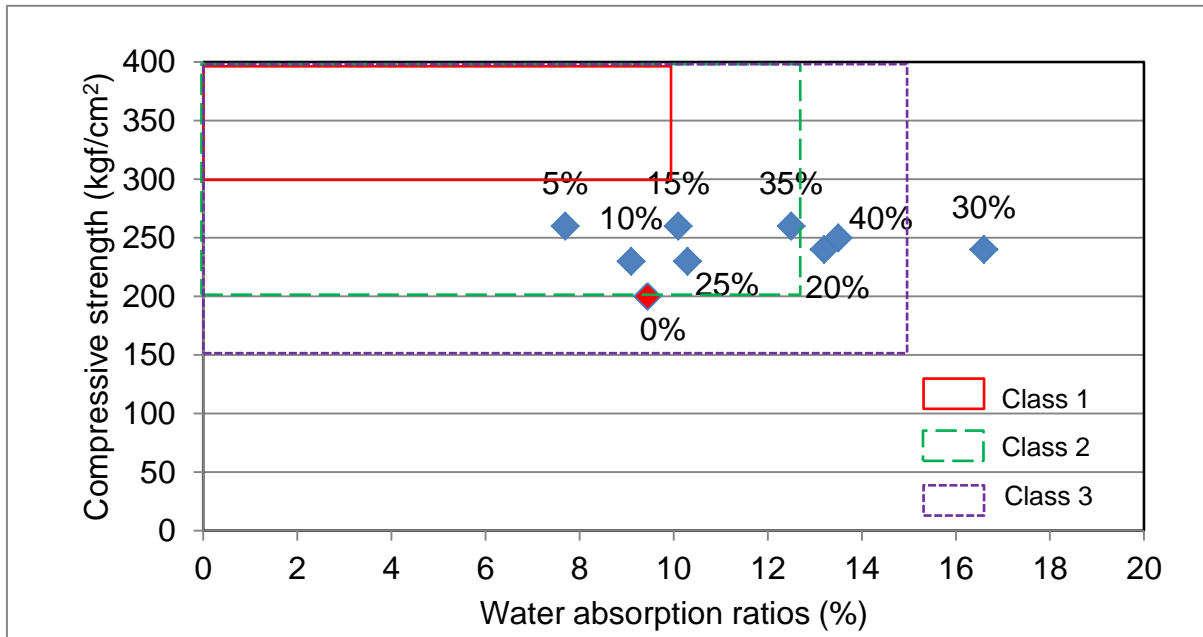


Fig. 4 Grade distribution chart of sintered bricks with different percentages of 4:1 silicon carbide and silicon mixture added to clay loam

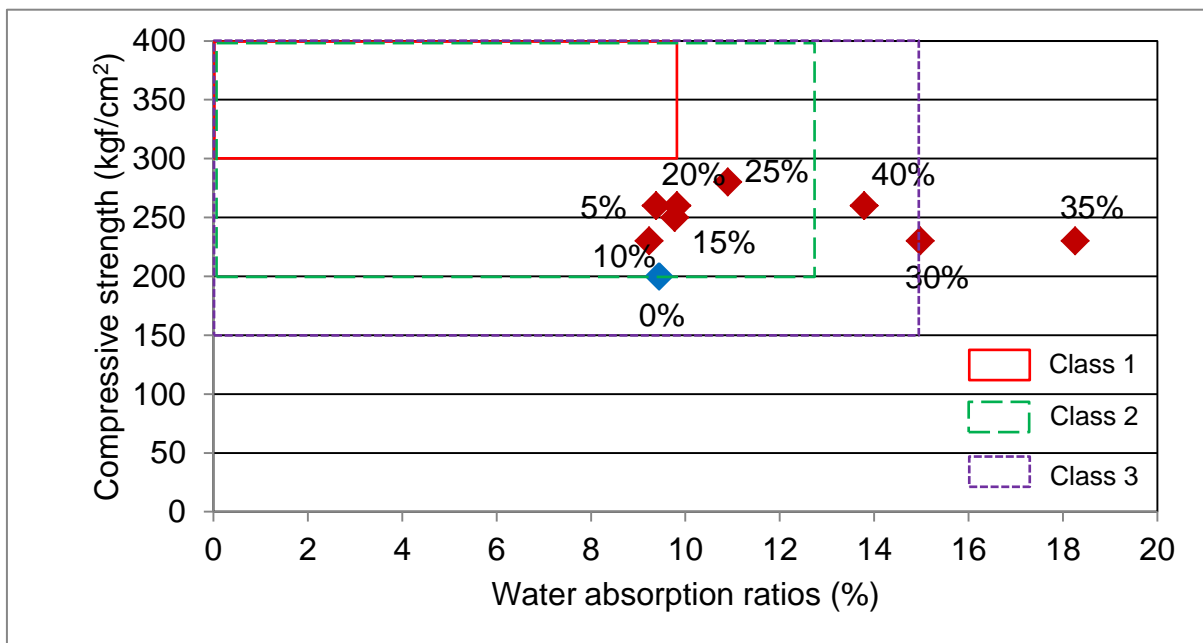


Fig. 5 Grade distribution chart of sintered bricks with different percentages of 3:1 silicon carbide and silicon mixture added to clay loam

To explore if the quality of the leftover construction soil will also affect the quality of brick when the silicon carbide and silicon mixture is added to the leftover construction soil, this research has selected the 4:1 silicon carbide and silicon mixture because it has shown optimal results in the clay loam experiment and added in the silt loam leftover construction soil at percentages ranging from 0% to 40%. The grade distribution chart of the silt loam bricks is shown in Fig. 6. The results show that bricks made from silt loam are more stable than bricks made from clay loam. When the percentage of the silicon carbide and silicon mixture added is 35%, the resulting bricks can reach the specifications of Class 3 bricks, with only 40% additions going beyond the acceptable standards. The silt loam bricks also show better performance with regard to water absorption and compressive strength than clay loam bricks after sintering.

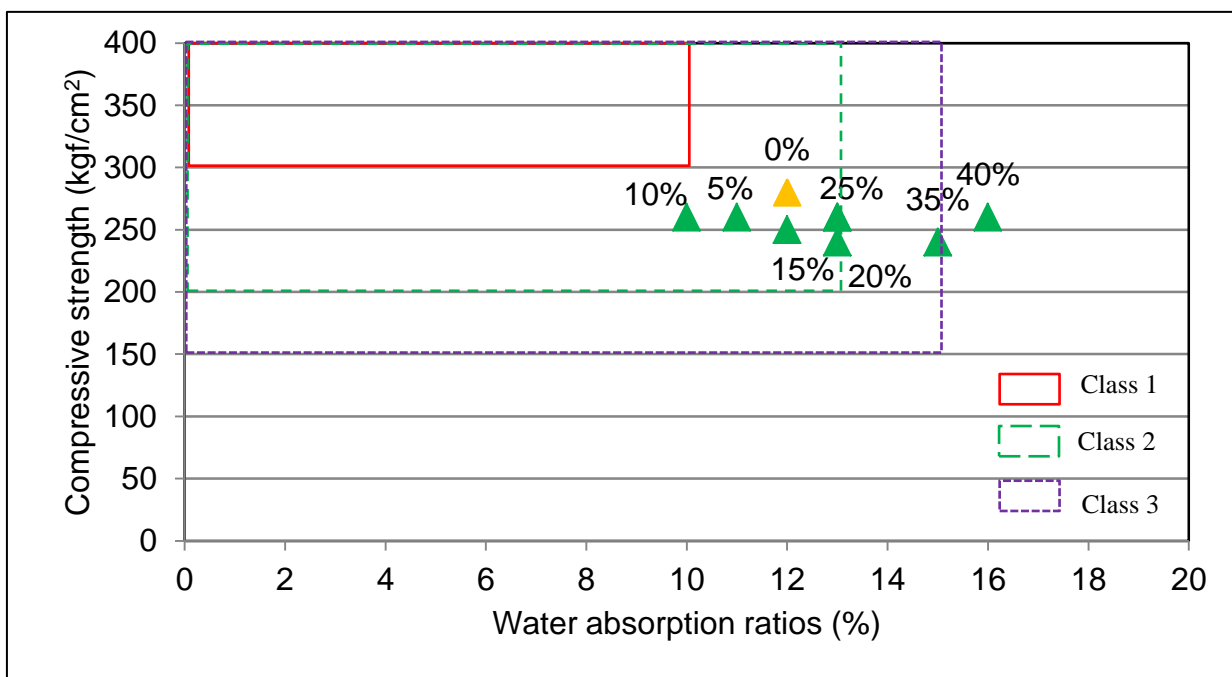


Fig. 6 Grade distribution chart of sintered bricks with different percentages of 4:1 silicon carbide and silicon mixture added to silt loam

### 3.2 Sintering results of the addition of low grade silicon carbide from solar power plants to leftover construction soil in Phase II

Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) is conducted on the low grade silicon carbide recycled from Plant T and Plant M to analyze the metal composition, as shown in Table 1, while the element composition analyzed using Elementar vario EL III is shown in Table 2. The low grade silicon carbide recycled from the plants mainly contain silicon and iron, while the aluminum content of the solid waste from Plant M (3,560 mg/kg) is much higher than that of Plant T (122 mg/kg), showing that the reactive aluminum content will affect the results of the brick sintering process. Furthermore, the proportion of carbon content from Plant M is



higher, showing a higher proportion of silicon carbide in the low grade silicon carbide solids (LGSC) solid wastes than Plant T. The hardness of silicon carbide is second only to diamonds and has the characteristic of a low thermal expansion coefficient, so it will contribute to the compressive strength of the bricks.

Table 1 Metal analysis of the LGSC solid wastes recycled from the two plants

| Analytical items | Plant T (mg/kg) | Plant M (mg/kg) |
|------------------|-----------------|-----------------|
| Si               | 537,000         | 286,000         |
| Fe               | 77,300          | 40,300          |
| Ca               | 845             | 1,090           |
| Mg               | 291             | 296             |
| Na               | 1,310           | 1,130           |
| K                | 487             | 1,030           |
| Al               | 122             | 3,560           |
| Mn               | 237             | 291             |
| Cd               | 2.36            | 1.56            |
| Cr               | 20.1            | 22.1            |
| Cu               | 1,510           | 810             |
| Ni               | 41              | 41              |
| Pb               | 11.3            | 2.32            |
| Zn               | 366             | 527             |

Table 2 Elemental analysis of the LGSC solid wastes recycled from the two plants

| Element items | Plant T (%) | Plant M (%) |
|---------------|-------------|-------------|
| C             | 1.90        | 13.06       |
| N             | 0.02        | 0.14        |
| H             | 0.05        | 1.69        |
| O             | 0.53        | 5.75        |
| S             | 0.25        | 0.70        |

The low grade silicon carbide solids (LGSC) recycled from the two plants are added to the leftover construction soil at percentages of 5%, 10%, 15%, 20%, 25%, 30%, 35%, and 40%. The grade distribution chart of the bricks made from the addition of low grade silicon carbide solids from Plant T to the clay loam and silt loam is shown in Fig. 7. In the experiments, only LGSC added at percentages of 0%, 5%, and 10% conform to the standards of Class 3 bricks. The bricks without addition of LGSC have a water absorption rate of 10.9% and compressive strength of 250 kgf/cm<sup>2</sup> and are

classified as Class 2 bricks. Bricks added with 5% and 10% of LGSC have a water absorption rate of 12.6% and 13.7%, respectively, and both have a compressive strength of 240 kgf/cm<sup>2</sup>; thus, they are classified as Class 3 bricks. Bricks added with 15% to 40% of LGSC have water absorption rates that exceed the Class 3 specifications but the compressive strengths remain within the scope of Class 3 standards. The results show that when LGSC is added to clay loam, as the quantity added increases, the water absorption rate will increase, and the compressive strength will decrease. Fig. 7 also shows the experiment results for the addition of LGSC recycled from Plant T to silt loam bricks. After the addition of LGSC, the bricks do not meet the standards of Class 3 bricks. The results show that although the bricks have compressive strengths within the scope of the Class 2 standards of 200 kgf/cm<sup>2</sup>, the water absorption rates are greater than the 15% standard required by Class 3; therefore, the groups do not conform to the scope of the standards. When the LGSC recycled from Plant T is added to the different leftover construction soils, the bricks show signs of poor water absorption performance, while the bricks sintered from silt loam have better compressive strength than those from clay loam.

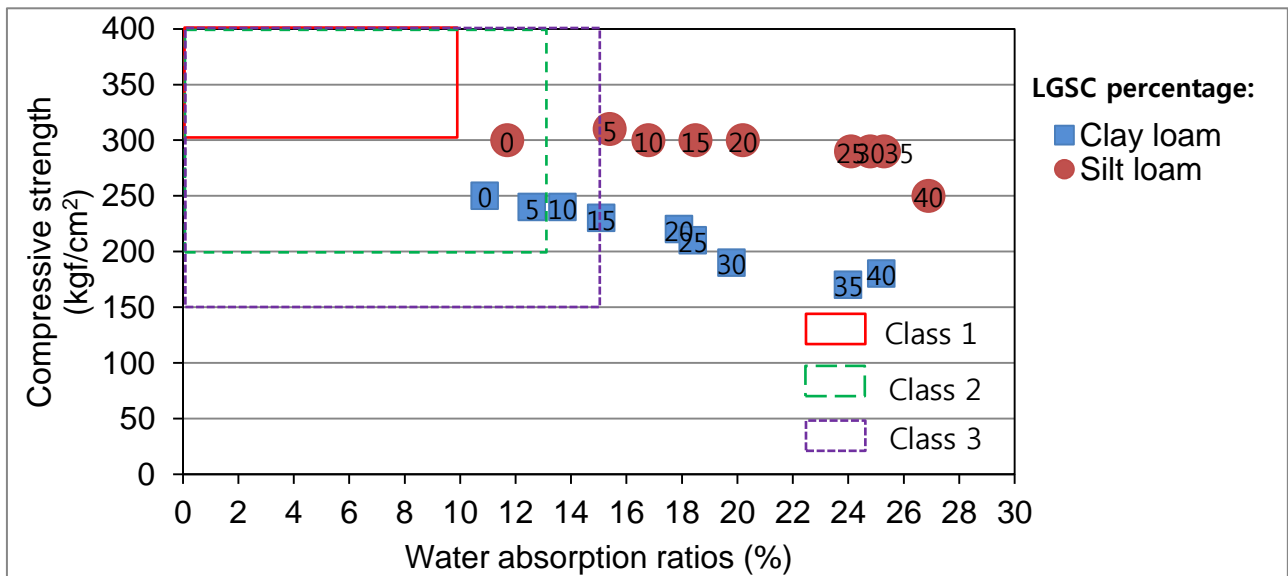


Fig. 7 Grade distribution chart of sintered bricks with different percentages of LGSC (from Plant T) added to leftover construction soil

The grade distribution chart of the bricks made from the addition of low grade silicon carbide (LGSC) from Plant M to the leftover construction soil is shown in Fig. 8. When LGSC from Plant M is added to the bricks made from clay loam, the bricks show compressive strengths higher than 200 kgf/cm<sup>2</sup>, which is within the scope of Class 2 bricks, but poor water absorption performance. The water absorption rate of the bricks added with 0%, 5%, and 10% LGSC is 10%, 12.7%, and 11.8% respectively, which is within the scope of Class 2 bricks. The water absorption rates of bricks added with 15%, 20%, and 30% LGSC are within the scope of Class 3 bricks. Bricks with higher percentages of LGSC added do not fall within the scope of Class 3 bricks. When the percentage of LGSC from Plant M added to clay loam is higher, the resulting bricks

have poorer water absorption performance, but when added with 25% of LGSC, the bricks show a significant increase in compressive strength. When the LGSC (from Plant M) is added to the silt loam, after sintering, only the water absorption rates of the four groups of bricks with 0%, 5%, 10%, and 15% LGSC added conform to the specifications of Class 2 and Class 3, while the others fail to meet the standards. However, the compressive strength of the bricks from all groups are higher than the Class 1 standards of 300 kgf/cm<sup>2</sup>, so bricks made from silt loam show a significant advantage in compressive strength than bricks made from clay loam.

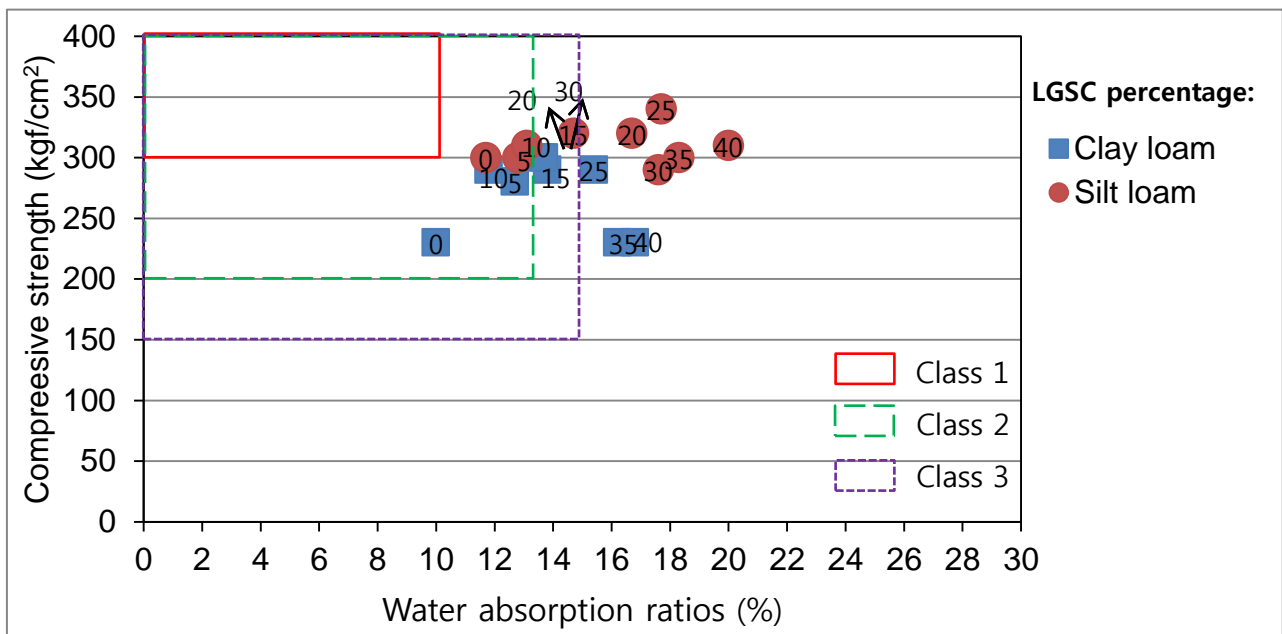


Fig. 8 Grade distribution chart of sintered bricks with different percentages of LGSC (from Plant M) added to leftover construction soil

### 3.3 Sintering results of the addition of low grade silicon carbide from solar power plants and waste clinkers to leftover construction soil in Phase III

The results from the addition of LGSC from Plant T and Plant M to clay loam and silt loam show that in all the experiments, the addition of LGSC will increase the water absorption rate of the brick samples. Therefore, in the third phase, a combination addition of 10% to 25% of LGSC from Plant T and 25% to 40% of LGSC from Plant M will be added, together with 5% of waste clinkers, to the leftover construction soil for brick sintering. As the waste clinkers contain defects after sintering, the waste clinkers are first crushed and pulverized into particles, after which the particles with a diameter of 0.4 mm or less were added to the brick sintering process. During low temperature sintering, the waste clinkers have low compactness, and the increase in pores results in an increased water absorption rate. At high temperature sintering, the waste clinkers have higher compactness, causing the water absorption rate to decrease. Therefore, the temperature of the brick sintering process in Phase III is increased from 1,020°C to 1,050°C.

The grade distribution chart of the brick samples made from the addition of LGSC from Plant T and 5% waste clinkers to the leftover construction soil is shown in Fig. 9. The graph shows that the brick samples made from clay loam have a significant drop in water absorption rates and an increase in compressive strength. The addition of waste clinkers increase the grades of the bricks to the Class 2 standards. The brick samples made from silt loam also show a sharp increase in grade levels, with the optimal condition being the addition of 15% of LGSC and 5% of waste clinkers to the silt loam. The resulting brick is elevated to meet Class 1 standards.

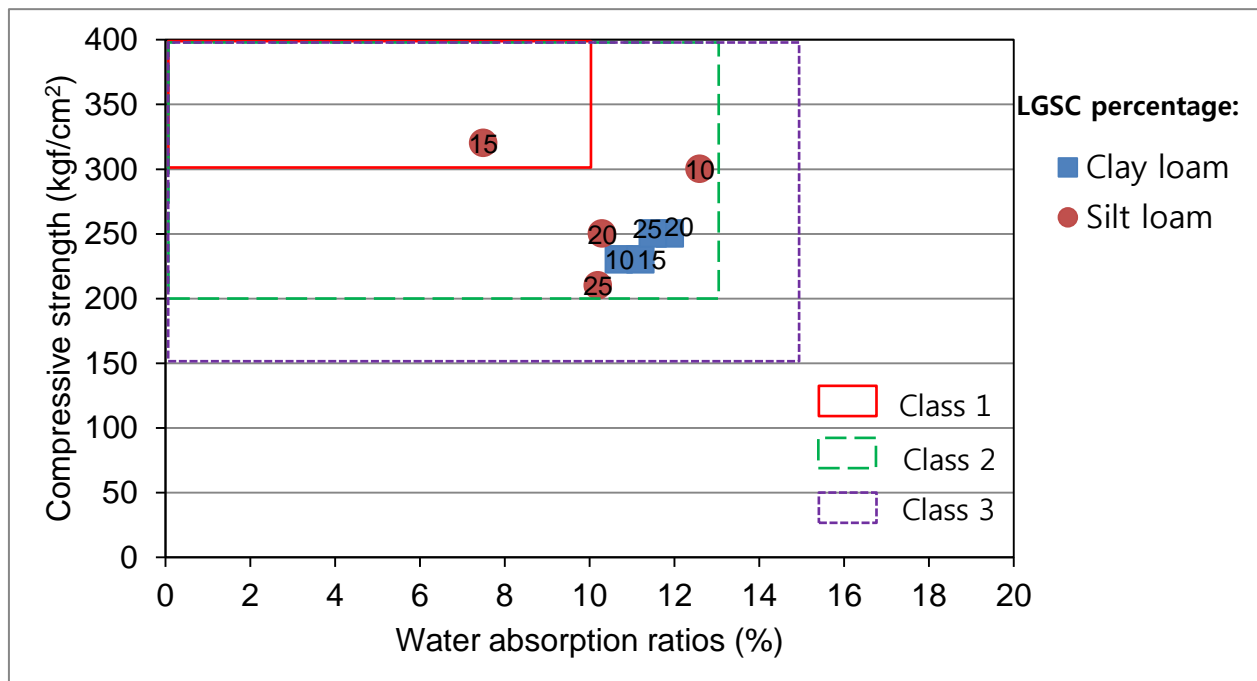


Fig. 9 Grade distribution chart of sintered bricks with different percentages of LGSC (from Plant T) and 5% of waste clinkers added to construction leftover soil

The grade distribution chart of the brick samples made from the addition of LGSC from Plant M and 5% of waste clinkers to leftover construction soil is shown in Fig. 10. The graph shows that the bricks made from clay loam exhibit a significant drop in water absorption rates while the compressive strengths are not significantly affected. The bricks made with the addition of the waste clinkers belong to Class 2. The bricks made from silt loam show a drastic drop in water absorption while the compressive strengths are not significantly affected. The bricks made with the addition of 25%, 30%, and 35% LGSC belong to Class 2, while the bricks made with the addition of 40% LGSC meet the standards of Class 3 bricks. The results show that the addition of 5% of waste clinkers can reduce the water absorption rates of the bricks made from the silt loam group. Although the increase in compressive strength is minor, the grade of the resulting bricks can be increased.

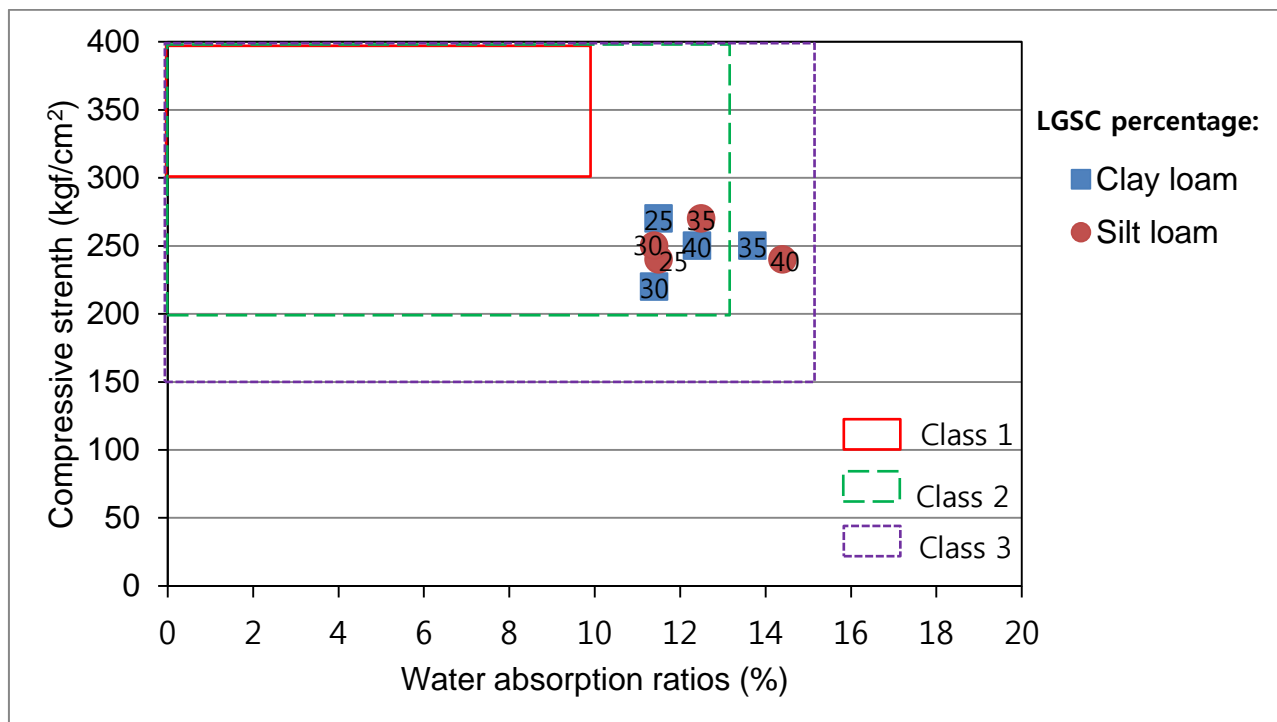


Fig. 10 Grade distribution chart of sintered bricks with different percentages of LGSC (from Plant M) and 5% of waste clinkers added to leftover construction soil

#### 4. CONCLUSION

Whether the 4:1 or 3:1 ratio of the silicon carbide to silicon mixture, the mixture does not affect the quality of the bricks and can be added to a maximum proportion of 25%. When the LGSC recycled from solar power plants is added to the leftover construction soil, the water absorption rate of the green bricks is affected. The higher the proportion added, the higher the water absorption will be. The compressive strength of bricks made from silt loam is better than that of bricks made from clay loam. When waste clinkers are added and the sintering temperature is increased to 1,050°C, a significant drop in the water absorption rate can be observed, while the compressive strength of the brick will experience a slight increase, thus improving the grade of the brick. In this research, the optimal mixture proportion is the addition of 15% of LGSC from Plant T and 5% of waste clinkers to silt loam, which will produce a brick with Class 1 specifications.

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