STANDARD SPECIFICATIONS FOR CONCRETE PAVING BLOCK IN JAPAN

Interlocking Block Association Tokyo, Japan

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SUMMARY

About 15 years have passed since concrete paving blocks were first introduced in Japan. Since introduction, the demand for this block has increased steadily year by year, especially the production thereof in 1980's has shown remarkable increase. Under such a background, it was an urgent matter to provide for the standard specifications for the purpose of promoting the sound spread of concrete paving blocks. In response to such a requirement, in 1987 Interlocking Block Association issued the Standard Specifications of the Association.
This paper describes the provisions of this Standard of the Association. This Standard specifies the provisions regarding the items listed below. ① Types of blocks, ② Quality of block (Appearance, strength, permeability), ③ Shapes, dimensions and dimensional tolerances of block, ④ Materials (Cement, aggregates, water, admixture, coloring admixture), ⑤ Manufacture, ⑥ Curing, ⑦ Tests (Flexural strength, compressive strength, permeability), ⑧ Inspection (Appearance, shape dimension, strength, permeability) and ⑨ Marking

1. INTRODUCTION

In 1973 concrete paving block (called "interlocking block" in Japan) was first introduced into Japan and around 1977 the mass-production thereof was started. Thereafter, in 1980's it has spreaded rapidly and the current annual production is about 3,000,000 m^2 and about 60 makers are making concrete paving blocks.
On the other hand, the standard specifications in Japan was defined individually by each maker pursuant to DIN Standards, in relation with the manufacturing engineering which was initially introduced from West Germany. Concurrently with rapid spread of the concrete paving block, thereafter, standardization of the design, construction and quality was required and, in reply to such a requirement, in 1983 Interlocking Block Technical Research Institute was established to start the preparatory work for the standardization. In addition, this Research Institute organized an individual working group for each item in order to prepare design manual, construction manual, quality standard, etc.
In 1985 this Research Institute was renamed "Interlocking Block Association" to subsequently promote the said standardization and in the same year the Association drafted tentatively the design manual, the construction manual and the quality standard. However, these involved mainly the suggestions and opinions of block makers. Thereafter, from the viewpoint that the standard should naturally involve the suggestions and opinions of users including public agencies, in 1986 the Interlocking Block Paving Research Committee consisting of the representatives from governmental authories (i.e. Ministry of Construction), road construction companies and the Association was newly organized to further promote the preparation of formal standards. Since then, this Committee has engaged in preparation of ① application guide, ② design manual for block pavement of walkway, bycycle way, square, etc., ③ design manual for block pavement of light and medium traffics, ④ construction manual and ⑤ quality standard and has already completed ②, ④ and ⑤. This paper introduces the quality standard, of these.

2. QUALITY STANDARD OF INTERLOCKING BLOCK

2.1 Scope of application

This Standard shall be applicable for the quality of concrete interlocking block mainly applied to pavement.

Remarks: The units and numerical values shown with { } in this Standard are those per the International Unit System (SI), added therein as references.

2.2 Types of blocks

Currently available interlocking blocks are classified into normal type, water permeability type, glass planting type, as shown in Table 1.

Table 1. Type of interlocking block

Type	Symbol	flexural strength	Coefficient of water permeability
Normal interlocking block	N-1(1)	50kgf/cm²(4.9N/mm²)	-
	N-2(2)		
Permeable interlocking block	P-1(1)	30kgf/cm²(2.9N/mm²)	1 x 10^{-2}cm/sec
	P-2(2)		
Grass planting - interlocking block	G-1(1)	40kgf/cm²(3.9N/mm²)	-

Note (1) Single-layer interlocking block of entire concrete layer.
(2) Double-layer interlocking block composed of mortar layer to color a surface and other internal concrete layers.

(3) When flexural strength test cannot be applied to blocks due to their shapes and other reason, compressive strength test is alternatively applied using a core specimen and the compressive strength obtained from the test shall be not less than 330 kgf/cm^2 {32 N/mm^2} for the normal interlocking blocks and not less than 170 kgf/cm^2 {17 N/mm^2} for water permeability interlocking blocks.

Interlocking blocks currently available in Japan are mainly classified as shown in Table 2. In addition, the relation between function and design are as shown in Fig. 1.

Table 2. Classification of interlocking block

Function	Normal type, Permeable type, Grass planting type, Guiding a blind pedestrian type.
Shape	Rectangle type, Square type, Hexagon type, Octagon type, Polygon type, Others.
Thickness	60mm type, 80mm type, 100mm type, 120mm type.
Design	Standard type, Decorated type.

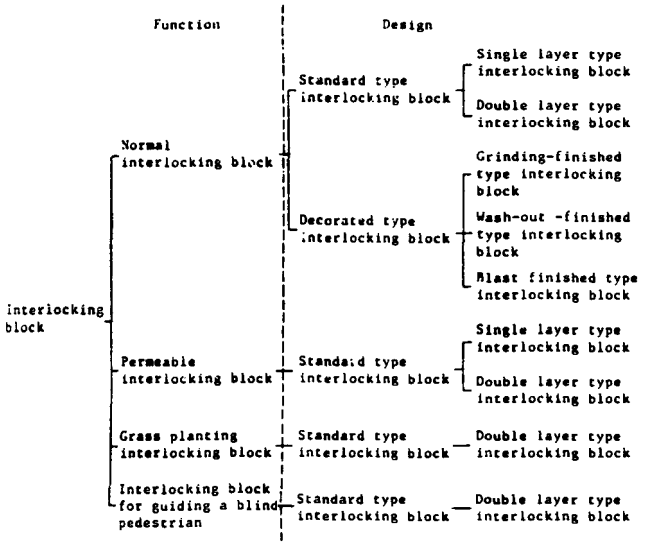


Figure 1. Classification of interlocking block

2.3 Quality

2.3.1 Appearance

Interlocking blocks shall not be free from harmful flaw, crack, break-off, deformation, etc.

2.3.2 Strength

The strength of interlocking block shall be not less than the strength requirements of Table 1 in the strength tests specified in Paras. 2.8.1 and 2.8.2.

2.3.3 Permeability coefficient

The permeability coefficient of permeable interlocking blocks shall be not less than 1 x 10^{-2} cm/sec in the water permeability test specified in Para. 2.8.3.

(1) Strength

Initially the compressive strength on the full-size block was specified, but thereafter it was altered to the flexural strength for easiness of test. Further, the specified strength values shown in Table 1 were defined considering the various standards in foreign countries, each maker's past strength data in Japan and the durability as paving material.

(2) Coefficient of water permeability

Generally, if its coefficient of water permeability is 1 x 10^{-2} cm/sec and over, the interlocking block can permeate the rain water of about 50 mm/h in rainfall strength completely into the ground. In addition, due to its water permeable ability almost identical to sub-base, the interlocking block enables smooth permeating of rain water into sub-base.

2.4 Shape, dimension and dimensional tolerances

2.4.1 Shape and dimension

The shapes and dimensions of interlocking blocks shall be as illustrated in appendix. Fig. 2 shows the length (L), width (W) and thickness (D) respectively.
The thicknesses shall be 60 mm, 80 mm in normal and permeable interlocking block and 100 mm, 120 mm in grass planting interlocking block respectively.

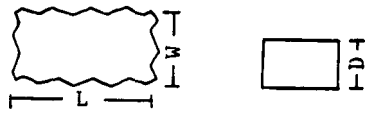


Figure 2.

2.4.2 Dimensional tolerances

The dimensional tolerances of interlocking blocks shall be as specified in Table 3.

Table 3. Dimensional tolerance

(unit:mm)

Type	L	W	D
Normal interlocking block	± 3	± 3	± 3
Permeable interlocking block			+ 5 - 1
Grass planting interlocking block			± 3

(1) Shapes and dimensions

The interlocking blocks in current use in Japan are as shown in appendix. As shown, the shapes and dimensions of those are a little different from each other depending on block makers. So, unified classification of interlocking block is extremely difficult.

(2) Dimensional tolerances

The dimensional tolerances were defined taking into consideration such as the standards in foreign countries, manufacturing method, actual application data, etc. Furthermore, regarding the dimensional tolerances of permeable interlocking blocks, the plus tolerances were defined a little bit larger and reversely the minus tolernaces defined smaller inproportionally.

2.5 Materials

2.5.1 Cement

Cement shall conform to the following standards. When white portland cement is used, it shall conform to the physical properties specified in the portland cement standard.

(1) JIS R 5210
(Portland Cement)
(2) JIS R 5211
(Portland Blast-furnace Slag Cement)
(3) JIS R 5212
(Portland Pozzolan Cement)
(4) JIS R 5213
(Portland Fly-ash Cement)

2.5.2 Aggregates

Aggregate shall be clean, very hard and durable and have proper particle size, and in addition it shall not contain injurious amounts of rubbish, dirt, organic impurities, thin stone pieces, long stone pieces.

2.5.3 Water

Water shall not contain injurious amounts of oil, acid, salt, organic impurities, which may adversely affect the quality of interlocking blocks.

2.5.4 Admixtures

Admixtures shall not give injurious affect to the quality of interlocking blocks.
Fly-ash and chemical admixture shall conform to the requirements of the following standards.

(1) JIS A 6201 (Fly-ash)
(2) JIS A 6204
(Chemical admixture for concrete)

2.5.5 Coloring admixture

Coloring admixture shall be inorganic matter and be excellently weather resistant and, in addition, shall not give injurious affect to the quality of interlocking blocks and the ambient environment as well.

2.6 Manufacture

2.6.1 Batching of materials

Batching of materials shall all be subject to the mass. However, water and liquid admixtures may be batched in a volumetric method or other precise method.

2.6.2 Casting

For block casting, concrete is filled in a metal mold and then compacted using a vibrator or other means from which the effect similar to the vibrator can be obtained.

2.7 Curing

Curing shall be performed in such a method that it can ensure the satisfactory quality of interlocking block.

2.8 Tests

2.8.1 Frexural strength test

In the frexural strength test, the span length (ℓ) of interlocking block shall be established as Table 4 and the blocks be set as illustrated in Fig. 3.

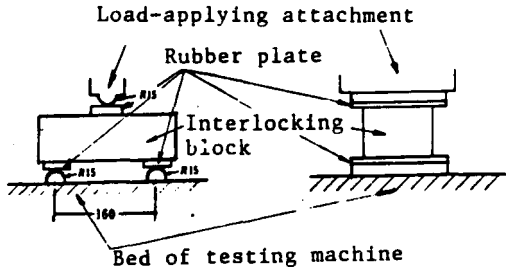


Figure 3. Testing machine

Table 4. Flexural span (ℓ)

(unit:mm)

Type	Span (ℓ)
Normal interlocking block	160
Permeable interlocking block	
Grass planting interlocking block	Two times or more the thickness

Calculate frexural strength as follows:

Normal and permeable interlocking blocks	$\sigma = \frac{24}{bd^2} P$
Grass planting interlocking blocks	$\sigma = \frac{1.5}{bd^2} P\ell$

where, υ : Frexural strength (kgf/cm^2)
P : Max. load (kgf)
b : Width of interlocking block (cm)
d : Thickness of interlocking block (cm)
ℓ : Span length (cm)

2.8.2 Compressive strength test

For compressive test use, core specimens shall be cut to $h/d \geq 1$ (h: height, d: diameter) and the ends of core specimens shall be finished smoothly by cement paste capping or other equivalent method. If the ratio of height to diameter of specimen is appreciably larger than one, make allowance for the ratio of height to diameter by multiplying the compressive strength by the applicable correction coefficient as shown in Table 5.

Table 5. Corrective coefficient

Height-Diameter ratio (h/d)	corrective coefficient	remark
2.00	1.12	When a h/d is between the values shown here, the correction coefficient shall be determind by linear interpolation.
1.75	1.10	
1.50	1.08	
1.25	1.04	
1.00	1.00	

2.8.3 Water permeability test

After measurement of its thickness and area, interlocking block shall set inside a frame as illustrated in Fig. 4 and then it be stationally kept together with the frame in a water tank, as illustrated in Fig. 5. In such condition, water shall be fed into the tank and, when the water level reaches a specific level, 30-second water outflow from the drain hole shall be measured.

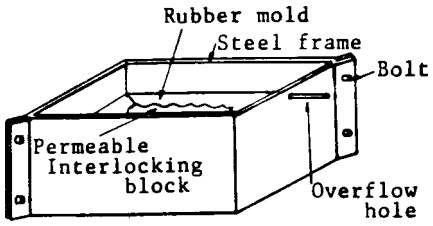


Figure 4. Water permeability test mold

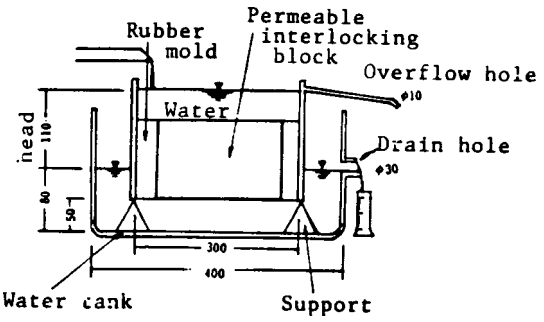


Figure 5. Water permeability test machine

From this water outflow, caluculate the permeability coefficient as follow:

$$\text{Permeability coefficient}_{(cm/s)} = \frac{\text{Thickness of interlocking block (cm)}}{\text{Difference of water head (cm)}} \times \frac{Q\ (cm^3)}{\text{Area of interlocking block}(cm^2) \times 30\ sec.}$$

2.9 Inspection

2.9.1 Inspection items

Appearance, shape, dimension, strength and water permeability shall be inspected.

2.9.2 Appearance

Appearance inspection shall be visually conducted for blocks at unit of pallet and these blocks shall be evaluated as acceptable if the blocks on the top stage of the pallet meet the requirements of Para. 2.3.1. If even one piece of these blocks fails to meet the specified requirements in this inspection, same inspection shall be conducted for 100% of blocks contained in the pallet, and they shall be evaluated as acceptable if they meet the specified requirements.

2.9.3 Shape and dimension

This inspection shall be conducted for two interlocking blocks sampled randomly from 1 lot equivalent to an area of 1000 m^2 and the lot shall be evaluated as acceptable if these two pieces meet the requirements of Subsection 2.4. If even one piece fails to meet the requirements, reinspection shall be conducted for additional 2.4 interlocking blocks sampled randomly from the same lot and, if these four meet the requirements of Subsection 2.4, the lot shall be all evaluated as acceptable. If even one piece of these four fails to meet, 100% inspection shall be conducted for the lot and, if the lot meets the requirements, it shall be evaluated as acceptable.

2.9.4 Strength

The strength tests specified in Paras. 2.8.1 and 2.8.2 shall be conducted for two interlocking blocks sampled randomly from one lot equivalent to 1,000 m^2. And, if these two pieces meet the requirements of Para. 2.3.2, the lot shall be all evaluated as acceptable. If even one piece fails to meet the requirements, reinspection may be applied. Reinspection shall be conducted for further 4 blocks sampled randomly from the same lot and, if even one piece fails to meet the requirements, the lot shall be all evaluated as NG (rejection).

2.9.5 Water permeability

The water permeability test specified in Para. 2.8.3 shall be conducted for two interlocking blocks sampled randomly from one lot equivalent

to 1,000 m³. And, if these two pieces meet the requirements of Para. 2.3.3, the lot shall be evaluated as acceptable. If even one piece fails to meet the requirements, reinspection may be applied to the lot. Reinspection shall be conducted for further 4 blocks sampled randomly from the same lot, per the requirements Para. 2.8.3, and, if these four pieces meet the specified requirements, the lot shall be all evaluated as accpetable. If even one piece fails to meet the requirements, the lot shall be all evaluated as NG.

2.10 Marking

Each pallet must be identified with following information.

(1) Manufacturer's name or its trade mark
(2) Manufacturing plant name or its abbreviation
(3) Casted date
(4) Type, shape, color and quantity of blocks

3. CONCLUSION

The national provisions relating to products are provided for in the standards, so called, Japanese Industrial Standards issued by the Japanese Industrial Standardization Committee after careful review and deliberation of the standard drafts submitted from societies, associations, enterprises. If interlocking blocks are spreaded more and more in the future, the Standard by the Association of Interlocking Block may possibly be transfered to one of the Japanese Industrial Standards. However, it is the Association's current intention to promote the steady spread of interlocking blocks under the existing Standard of the Association.

APPENDIX

