EVALUATION ON INTERLOCKING BLOCK IN THE GREAT HANSHIN EARTHQUAKE

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ABSTRACT

On January 17, 1995 at 5:46 a.m., an earthquake directly above its epicenter with 7.2 on the Richter scale broke out around Awajishima Island and hit mainly the city of Kobe and Hanshin District. Buildings and residences of modern technologies easily collapsed, the Shinkansen, brigdes of highways and the transportation systems collapsed all over and fires broke out everywhere. The unprecedented disaster demonstrated how fragile the urban life is for people. Interlocking Block Pavement Engineering Association underwent investigations in April 1995 on damage mainly of interlocking block, other paving materials and pavements using those materials. The results of the investigations were summed up and presented in the Pave Israel '96 under the title "The Examination Report on the 1995 Hyogo-ken Nanbu Earthquake".
In March 2000 after 5 years from the Great Hanshin Earthquake, the Association underwent questionnairing on post-earthquake conditions of pavement materials and repairing works in order to obtain relative evaluations on each pavement material and interlocking block. This paper reports on the results of the questionnairing.

OUTLOOK OF THE INVESTIGATIONS

The towns and streets which sustained big damage have restored as they were before after 5 years from the Great Hanshin Earthquake. Interlocking Block and Pavement Engineering Association underwent questionnairing in March 2000 about the damage situation by the earthquake and construction for restoration mainly of interlocking block and other pavements. The constituent of the answerers is shown in Fig.-1. The answerers were 355 people from the public sector, architectural offices, construction companies and general citizens. 90% of the answerers is engaged in construction-related fields like architectural offices and construction companies and 70% have experiences of working for the construction of restoration in actual damaged sites. Their ages are mostly between 35-45 with the majority playing a central part for restoration works.

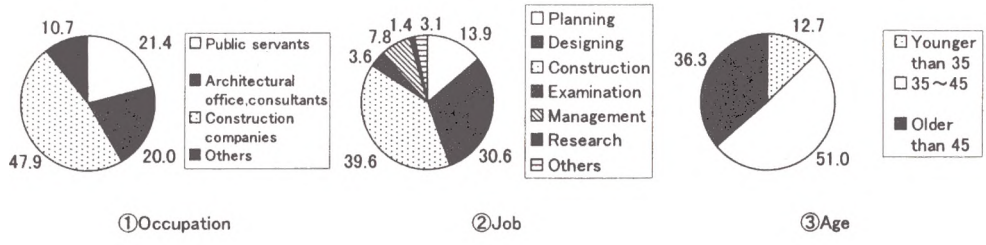

Fig.-1 The Constituent of the Answerers of the Questionnair

The inquiry was made for the following 6 questions to be chosen with regard to pavement materials

Q1:Which are your impressions after seeing the post-earthquake conditions of pavement of walkways, roadways and public spaces?

Q2:Let us ask you about the post-earthquake state of repairs

Q3:Have you seen paving materials which are different from before and after the Disaster?

Q4:Let us ask you about the evaluation on pavement materials for post-earthquake restoration

Q5:Let us ask you about the reasons for Q4

Q6: Have you seen restoration works of interlocking block?

We also underwent investigations on the recycling rate examining the delivery data of interlocking block for each manufacturer with regard to the restoration of the Disaster

RESULTS OF THE QUESTIONNAIRE

We sum up the results of the questionnaire by each question as follows.

Question 1: What are your impressions after seeing the post-earthquake conditions of pavement of walkways, roadways and public spaces?

The results of the questionnaire of the impressions on each pavement material are shown in Fig.-2. They have strong impressions on pavements of tiles, flags and asphalt being badly broken and dangerous. The reason is thought to be that the pavement materials are relatively thin to be easily broken and scatter around by seismic movement.

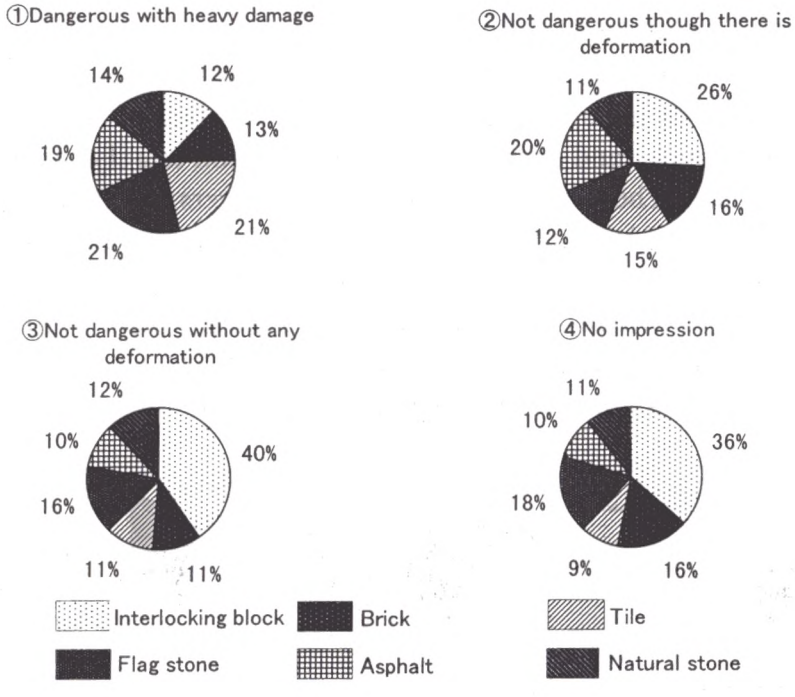

Fig.-2 Impressions on Pavement Materials immediately after the Disaster

On the other hand, many people thought such pavement materials like interlocking block and brick which are relatively thick and small in size were not so dangerous. The impressions were split depending on thickness and size of pavement materials. There were both impressions on flags.

Question 2:Let us ask you about the post-earthquake state of repairs

The results of the questionnaire of the impressions on the post-earthquake state of repairs are shown in Fig.-3. A majority answered "Restoration is easy" with interlocking block pavement. People answered, "It takes time for restoration" are 7% of the total and it is said that interlocking block is an easier pavement material for restoration than other materials. They answered roughly the same to the inquiry, "Is it difficult to dispose of broken wastes?"

Question 3: Have you seen paving materials which are different from before and after the Disaster?

The results of the questionnaire of the kind of paving materials before and after the Disaster are shown in Fig.-4. The same paving materials as before the Disaster were apt to be used after the Disaster, too. But asphalt pavement tended in many cases to be changed to other paving materials.

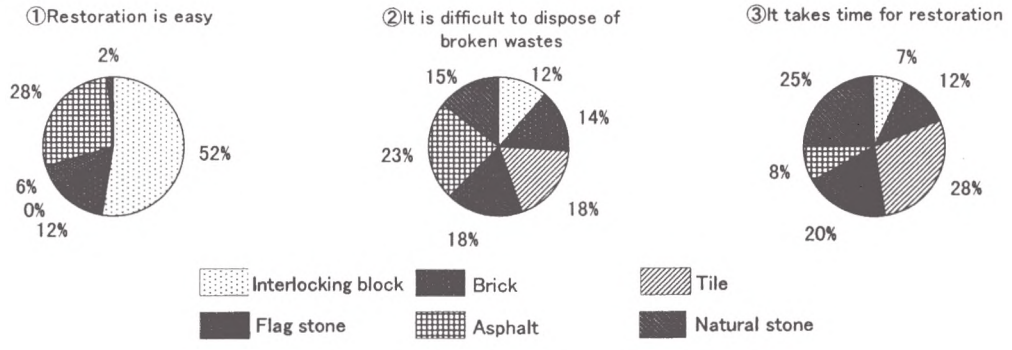

Fig.-3 Impressions on Repairing Work

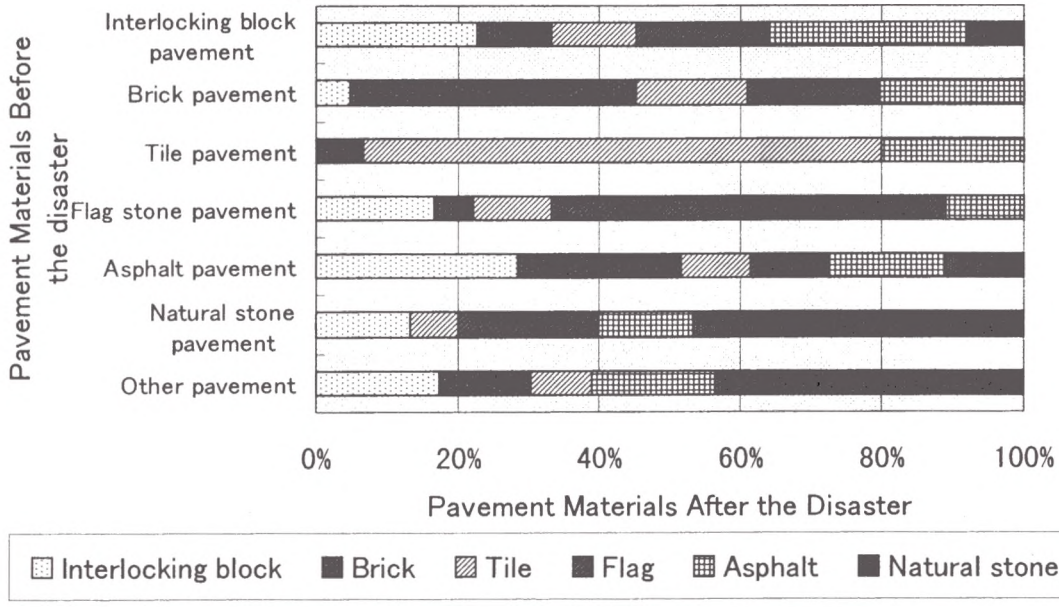

Fig.-4 Pavement Materials Before the Disaster

Question 4:Let us ask you about the evaluation on pavement materials for post-

earthquake restoration

The results of the questionnaire of the impressions on pavement materials after the restoration works are shown in Fig.-5. Interlocking block and asphalt pavement gained better evaluation than other materials. There was only 1% of the people who answered that interlocking block pavement is inferior to others. On the other hand, flags and natural stones were evaluated "inferior to other pavement materials".

Question 5: Let us ask you about the reason for Q 4

The results of the questionnaire of the reason for Q4 are shown in Fig.-6. The reasons why interlocking block gained better evaluation than the other pavement materials in Q4 are because there is less damage of pop-up, breakage and chipping of block than other pavement materials and because restoration works were easier with blocks recycled.

Question 6: have you seen restoration works of interlocking block?

The results of the questionnaire of restoration works of interlocking block pavement are shown in Fig.-7. More than half of the restoration works of interlocking block is partial repairing works, that is, the damage was relatively small and it was restored with partial repairing only. The restoration works gave good impressions like "It is good as it can be reused" and "Restoration works look easy".

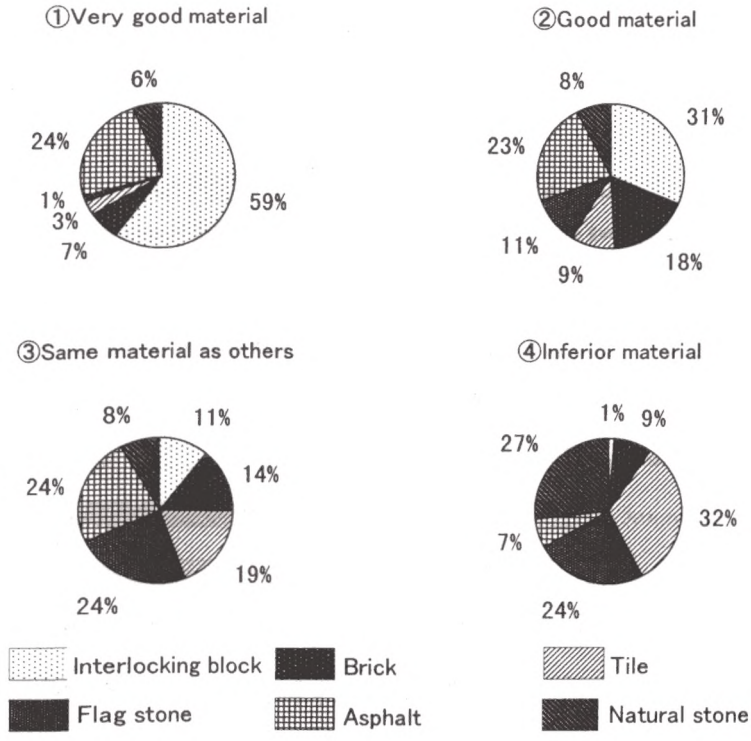

Fig.-5 Evaluation on Pavement Materials after Restoration

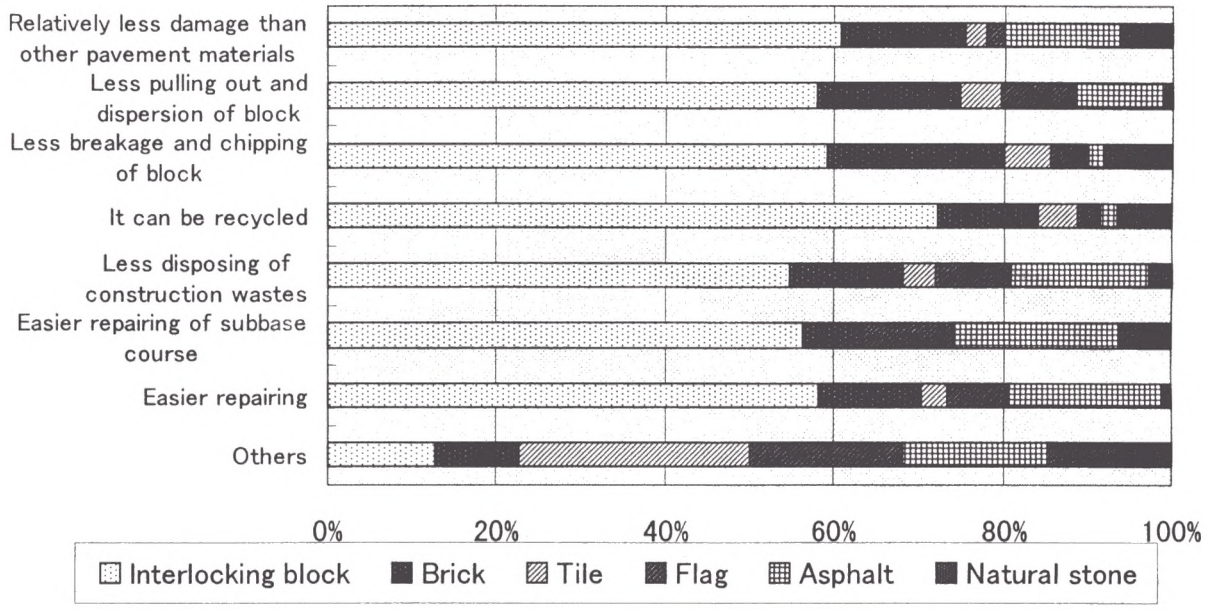

Fig.-6 Impressions on Restoration Works

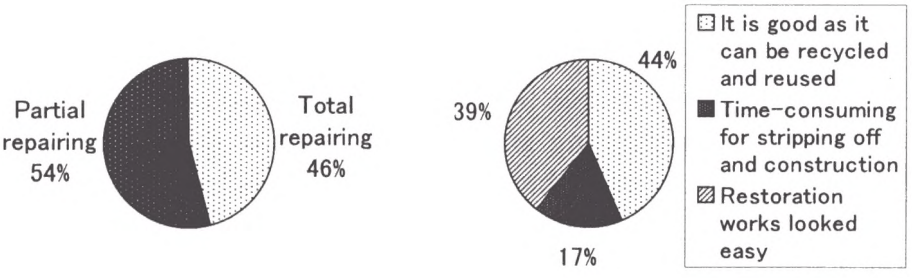

Fig.-7 Restoration Works of Interlocking Block Pavement

INVESTIGATIONS ON THE RATE OF REUSE OF INTERLOCKING BLOCK

The results of investigations covering interlocking block manufacturers in Kobe area on the deliveries of new blocks in relation to restoration works are shown in Table 1. The repaired area of interlocking block pavement totaled 48,239 m2 where new blocks used were only7,645 m2, that is to say, 84% of the blocks used before the Disaster were reused. These figures well support the answer in the results of the questionnaire "Possible to reuse blocks".

Table 1 Rate of Reuse of Interlocking Block

No.	Constractor	Project	Location	Application	Repaired Area (m^2)	New blocks (m^2)	Reused blocks (m^2)	Rate of reuse (%)
1	Kobe-shi	Yamate trunks	Higashi-nada ward	Walkways	1,320	237	1,083	82
2	Ministry of Construction	Route#2	Akashi-shi	Walkways	1,877	180	1,697	90
3	Central Racing Society	Race track stand	Takarazuka -shi	Around stand	8,264	1,238	7,026	85
Other constructions(52 project)			—	—	36,778	5,990	30,788	84
Total			—	—	48,239	7,645	40,594	84

CONCLUSIONS

The questionnairing about the damage situation mainly of interlocking block and other pavement materials and about construction for restoration was carried out this year after 5 years from the Great Hanshin Earthquake. As a result, the evaluation of interlocking block pavement was very good with regard to both the situation immediately after the Disaster and the restoration works compared to the other pavement materials.At the outbreak of the earthquake, they first criticized interlocking block pavement that the scattered blocks obstructed the way for evacuation as blocks did not break into pieces like clay tiles. But when it came to restoration with the damaged areas suffering fantastic traffic paralysis, reusable interlocking blocks seem to have greatly contributed to the restoration as transporting and disposing of the materials were saved. Public officers re-evaluated interlocking block which is constructed in a dry system using joint sand and it was finally judged as the optimum material for such a seismic country as Japan.