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**GUÍAS TÉCNICAS PARA IN-SITU RECICLACIÓN DE
BASE CURSO EN JAPÓN**

**TECHNICAL GUIDELINES FOR IN-SITU RECYCLING OF
BASE COURSE IN JAPAN**

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RESUMEN

En 1976, el primer ensayo de in-situ reciclación de base curso ha sido hecho en camino rural de Japón. Después de muchos ensayos y experimentos en laboratorios, Japón Camino Asociación publicó una guía técnica titulada “Guías técnicas para in-situ reciclación de base curso” en 1987.

Para Administradores y Contratistas de caminos, la Asociación condujo un estudio nacional en 1996 y revisó los impactos de las Guías y su suficiencia. Una de las conclusiones fue que las Guías se aplican bien al campo de pavimento y la cantidad de las obras de reciclación está aumentando después de la publicación de las Guías.

Se estima que esta técnica está aplicándose a un área de más de 2,500,000 m² por año. Acerca de 90% de las obras han sido construido en caminos de poco volumen, como caminos rurales, calles y avenidas.

Como materiales de adición para el método de reciclación, las Guías especifican ‘cemento’ y ‘cemento + emulsión bituminosa.’ La mayor parte de in-situ reciclación de base curso para pavimentos flexibles ha sido construido con cemento + emulsión bituminosa. Una razón por esto es que la industria material es muy activa de promover esta técnica, y la otra es que la espesura de base curso reciclado que emplea solamente cemento es más gruesa que un curso de cemento y emulsión bituminosa.

Obras de in-situ reciclación también han sido desempeñado utilizando cemento y espuma bituminosa porque las nuevas máquinas avanzadas fueron importadas a Japón y un asfalto de cemento y espuma es valorado como una solución más económica.

ABSTRACT

In 1976, The first trial of in-situ recycling of base course was made in a rural road in Japan. After many trials and laboratory tests, Japan Road Association issued a guideline called “Technical Guidelines for in-situ recycling of base course” in 1987.

Towards road administrators and contractors, the Association conducted nationwide survey in 1996 and reviewed the impact of the Guidelines and sufficiency of it. One of the conclusion is “The Guidelines is well applied into the field of pavement. The amount of recycling works is increasing after publication of the Guidelines.”

It is said that the estimated annual applied area of this technique is more than 2,500,000 m²/year. And about 90 % of the work were operated on low volume roads like rural roads and city streets.

As additive materials for the recycling method, “ cement ” and “ cement + bituminous emulsion ” are specified in the Guidelines. Most of the in-situ recycling of base course of the existing flexible pavements, however, seem to be carried out with cement + bituminous

emulsion. This is partly because the material industry is very active in promoting this technique, and partly because the thickness of the recycled base course with cement alone is thicker than that with cement + bituminous emulsion .

However, in-situ recycling with cement + foamed bitumen have been recently performed in several projects. This is because new advanced machines have been imported from abroad, and recycled base course with cement +formed asphalt is evaluated as a more economical solution.

PALABRAS CLAVE

Guías técnicas, in-situ reciclación, base curso, cemento, emulsión de cemento y asfalto

KEY WORDS

Technical guidelines, in-situ recycling, base course, cement, cement asphalt emulsion

1. TECHNICAL GUIDELINES IN JAPAN

This Chapter will provide highlights, which are concept, structural design and restrictions, mix design and construction, from a guideline called “Technical Guidelines for in-situ recycling of base course” issued by Japan Road Association in 1987 (1).

1.1 Concept

After being added of binder (cement , or cement + bituminous emulsion) , the deteriorated asphalt layers and their lower existing granular basecourse are pulverized , mixed and compacted together at the site, so that the compacted recycled base course acts as the base course for a new asphalt pavement.

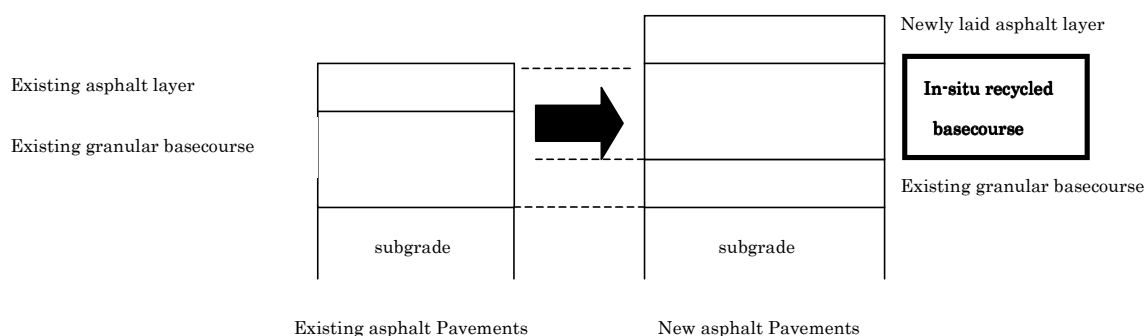


Figure 1: Concept of in-situ recycling of base course

1.2 Structural design and restrictions of the technique

This technique is allowed to apply to the place where the maximum thickness of the existing asphalt layer should be 15cm so that the pulverization can be surely done .

New asphalt pavement with this in-situ recycled base course is applied to low volume roads because there have not been sufficient data to validate the long-performance under heavy traffic conditions .

Table 1: Restriction of the technique

Traffic Category	Commercial Vehicles (/day/direction)	The use of in-situ recycled base course
L	< 100	Allowed
A	100 X < 250	Allowed
B	250 X < 1000	Allowed
C	1000 X < 3000	Not allowed
D	3000 X	Not allowed

The thickness of in-situ recycled base course is as follows;

Table 2: The thickness of in-situ recycled base course

Material	Maximum thickness (cm)	Minimum thickness (cm)
In-situ recycled basecourse with cement	30	15
In-situ recycled basecourse with cement + bitumonous emulsion	30	10

Equivalent layer coefficients of in-situ recycled basecourse are as follows;

Table 3: Equivalent layer coefficient of in-situ recycled base course

Material		Equivalent layer coefficient	Quality
In-situ recycled basecourse	with cement	0.50	Unconfined compressive strength: 2.5MPa
	with cement + bituminous emulsion	0.65	Special specified test and value as shown in other part
Reference: Virgin material	Cement treated base	0.55	Unconfined compressive strength: 3.0MPa
	Asphalt treated basecourse	0.80	Marshall Stability \geq 3.5kN
	Granular basecourse	0.35	Modified CBR \geq 80

Lean concrete base course ,that has high strength and is widely used in Europe, is not used In Japan either for concrete pavements or for asphalt pavement. According to the research of Public Works Research Institute (PWRI) , these equivalent layer coefficient values and specified qualities were decided by the performance analysis of many experimental roads and these strengths. The research showed that in-situ recycled base courses with unconfined strength value of 3.0MPa result in reflective cracking.

1.3 Mix design

The flowchart of choice of additive and mix design is shown in Figure 2.

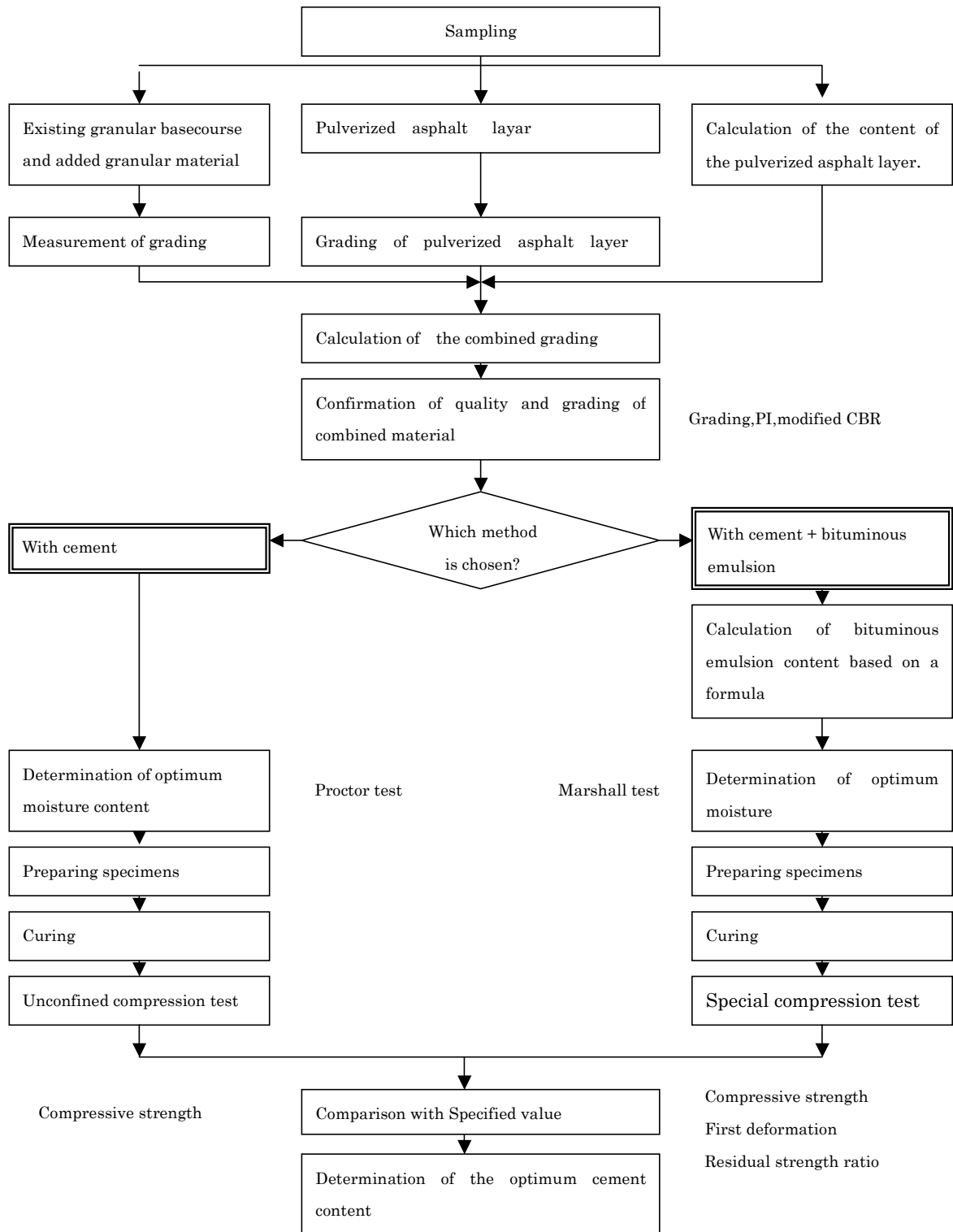


Figure 2: Flowchart of choice of additive and mix design

1.3.1 Testing of the pulverized asphalt layer and the existing granular basecourse

- 1) Sampling of the pulverized asphalt layer. If sampling of the pulverized asphalt layer in advance is difficult, the following grading can be used to calculate the combined grading.

Table 4: Grading of pulverized asphalt layer

Sieve (mm)	Passing (%)
50	
40	100
30	85
25	75
20	65
13	50
5	25
2.5	15
0.074	0

- 2) Sampling of the existing granular basecourse, and measurement of grading follows.
- 3) Calculation of the combined grading. It is recommended that the combined grading is within the specified grading range shown in Table 5. If the combined grading is out of grading range, adding granular material, like crusher-run, is recommended. And it is also recommended that combined material has the property shown in Table 6 .

Table 5: Recommended grading of combined material

Sieve (mm)	Passing (%)
50	100
40	95 ~ 100
20	50 ~ 100
2.5	20 ~ 60
0.074	0 ~ 15

Table 6: Recommended property of combined material

Item	Recommended property
Modified CBR	Not less than 20
PI (particle passing 0.4mm sieve)	Not more than 9

1.3.2 Mix design of recycled basecourse with cement alone

- 1) Determination of optimum moisture content by proctor compaction test (Specimen details: diameter 10cm, length 12.5cm, cylinder) with cement content of 4%.
- 2) Preparing specimens with cement contents ranging from 1 to 5%
- 3) Unconfined compression test after 7days curing in air
- 4) Determination the optimum cement content where compressive strength shows 2.5MPa.

1.3.3 Mix design of recycled basecourse with cement +bituminous emulsion

- 1) Calculation of bituminous emulsion content based on a formula that depends on sieve analysis of the combined grading(2.5mm , 0.074mm) and the content of the pulverized asphalt layer.
- 2) Determination of optimum moisture content by compaction test(Specimen details: diameter 10cm, length 6.8cm, Marshal size, Marshal compaction 50 blows at each side)with 2.5% cement content .
- 3) Preparing specimens with cement contents ranging from 1 to 5%.
- 4) Special compression test after 6 days curing in air and 1day curing in water
- 5) Determination of the optimum cement content where compressive strength, deformation and residual strength ratio meet the specified values in the following table.

Table 7: Requirement for optimum cement content

Item	Requirement
Compressive strength(MPa) σ_1	1.5 ~ 3.0
The 1st deformation(1/100cm) ϵ_1	5 ~ 30
Residual strength ratio (%) $\sigma_2 / \sigma_1 \times 100$	Not less than 65

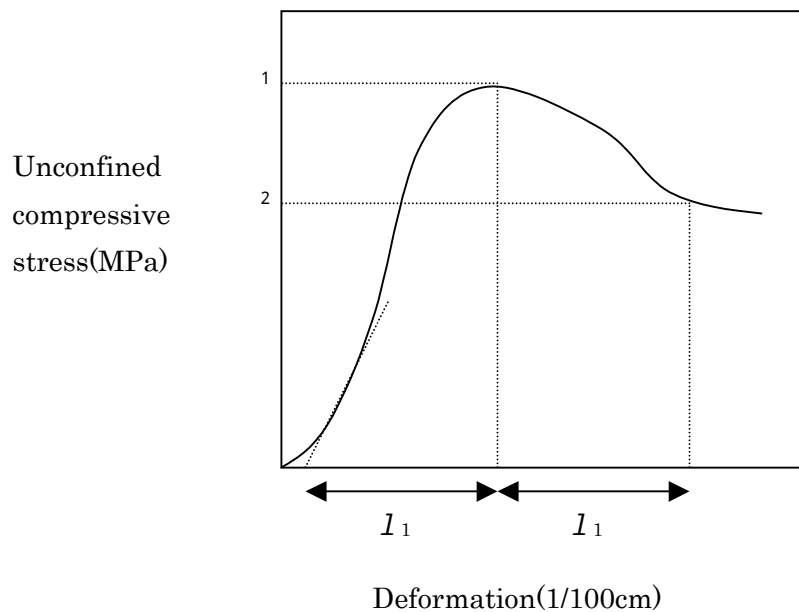


Figure 3: Stress-Deformation curve

1.4 Construction

Typical construction process of in-situ recycling is shown in Figure 4.

1.4.1 Job process

- 1) Spreading cement manually or using machineries on the deteriorated existing asphalt layer.
- 2) Pulverizing and mixing both the existing asphalt layer and existing basecourse, with adding water or bituminous emulsion to the mixture.
- 3) Trimming by motor grader
- 4) Compaction by tire roller and steel roller. If the thickness of the recycled basecourse is over 20cm, the use of vibratory roller is recommended.
- 5) Spraying of bituminous emulsion soon after compaction, and curing

1.4.2 Quality control

The quality is controlled with the method and frequency shown in Table 8.

Table 8: Method and frequency of quality control

Item	Method	Frequency	Remarks
Cement content	All quantity used	-	-
Bituminous emulsion content	All quantity used	-	-
Density	JIS A 1213	Per 1000m ²	Compaction Degree: Not less than 93%
Water content	JIS A 1203	1-2 times/day	-

1.5 Supplementary remarks

- 1) The examples of pulverizing and mixing machine used in Japan are shown in Table 9.

Table 9: Pulverizing and mixing machine used in Japan

Manufacture	Model	Type	Mixing Width(m)	Mixing Depth(m)
WIRTGEN • Japan	WR2500	Wheel	2.438	0.5
KOMATSU	GS 360-2	Wheel	1.98	0.4
SAKAI	PM500	Wheel	2.0	0.4
NIPPON • BOMAG	MPH120R	Wheel	2.1	0.39

- 2) Summary of in-situ recycling project is shown in Table 10 and Table 11. Concerning the type of cement, in most cases, ordinary Portland cement is used. But in some cases where the job site is located in a town, special cement like dust-proof solidifying cement is also used.

Table 10: Summary of in-situ recycling project in 1988 (2)

Material	Total No. of projects	Average cement content(%)	Average unconfined compressive strength (MPa)	Average bituminous emulsion content(%)
In-situ recycled basecourse with cement	130	4.9	2.36	-
In-situ recycled basecourse with cement + bituminous emulsion	174	3.0	-	4.7

Table 11: Summary of in-situ recycling project in 1993 (3)

Material	Total No. of Projects sampled	Average cement content (%)	Average OMC (%)	Average bituminous emulsion content(%)	Average special unconfined compressive strength (MPa)	Average compaction degree(%)
In-situ recycled basecourse with cement + bituminous emulsion	51	2.6	5.4	4.7	2.26	98.1

3) In-situ recycled basecourse using the old asphalt pavement with in-situ recycled basecourse was experimentally tried in 1995. That means in-situ re-recycled basecourse. It is reported that the construction was done well because of the use of the high-capacity pulverizing and mixing machine. As for the long term performance is being surveyed.

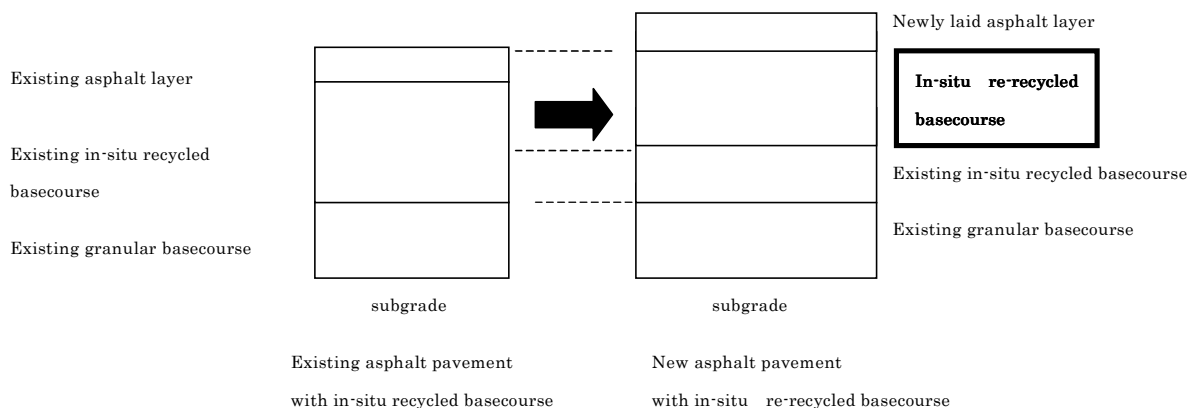


Figure 5: Concept of in-situ re-recycling of base course

2. IMPACT OF GUIDELINES

This Chapter will provide outline and results of the nationwide questionnaire survey conducted by Japan Road Association in 1996 towards road administrators and contractors (4).

2.1 Outline of the survey

1) Themes to be approached

Questionnaire survey aimed to approach the following themes;

- Strategy of extending the application of recycling technologies
- Evaluation of sufficiency of recycling technology
- Evaluation of quality of recycled materials and recycled additives
- Problems to be solved, concerning mix design, mixing, construction, quality control and testing

2) Organizations concerned

Questionnaires were sent out to 113 organizations and collected from 101 of them.

Table 12: Organizations concerned with the questionnaire survey

Category	Central / local	No. of organizations Questionnaire sent	No. of organizations Questionnaire collected
Road Administrator	Central	14	63
	Local	59	
Contractor		40	38
	Total	113	101

2.2 Results of the survey

1) General

In-situ recycling base course technology based on the Guidelines was well applied mainly to low volume traffic roads such as prefectural roads and municipal roads. It was evaluated as economical technology because it can save disposal cost of pavement wastes.

Seven years and half passed since the Guidelines had been published. The Guidelines had, however, no big problem to be revised urgently. In order to extend application of this technology, it is necessary to develop the simplified method of preparatory investigation and effective method to prevent the particle materials during operations.

2) Additive

From the viewpoint of additives, base course with cement has 40 % of share, and base course with cement + bituminous emulsion 60 %. Advantages of using cement + bituminous emulsion are as follows;

- Equivalent layer coefficient is bigger than that of base course with cement only
 - Possibility of cracking is lower than that of base course with cement only
- Etc.

3) Construction

Main complaints raised from road users and residents along the roads on which recycling projects were carried out are as follows;

- Vibration, noise and particle materials from construction equipment

- Scattering of cement

Etc.

Main difficulties raised from road administrators and contractors are as follows;

- To control the height of base course surface influenced by the expansion volume of the base course after mixing
- Restrictions of the sites to be applied

Etc.

4) Quality control and testing

In order to examine the quality of the project, road administrators preferred to use sampling test together with test based on the data collected during the project. Contractors had no intention to use sampling test.

CONCLUSIONS

- 1) The Guidelines is well applied into the field of pavement. The amount of recycling works is increasing after publication of the Guidelines
- 2) Seven years and half passed since the Guidelines had been published. The Guidelines had, however, no big problem to be revised urgently.
- 3) Main complaints raised from road users and residents along the roads on which recycling projects were carried out are vibration, noise, particle materials and scattering of cement.
- 4) The material industry's active promoting is one of the reasons most of the in-situ recycling of base course of the exiting flexible pavements is carried out with cement + bituminous emulsion.

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