Barrier Free Roads on Center Street in Takamatsu City

(Toward the Safe, Comfortable Traffic Road Sections for Pedestrians and Bicycles)

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ABSTRACT: Shikoku Bureau, Ministry of Land, Infrastructure and Transport has proceeded the barrier-free designed project for a sidewalk of the Chuo Street in Takamatsu-city, a city area of National Highway No.11 and No.30 from 2006 to 2009 based on "Takamatsu city traffic barrier-free specific plan" which is made with related authorities.

The number of bicycles in Kagawa prefecture is the largest in Japan and, in Particular in Takamatsu city, the numbers of bicycles and bicycle accidents are twice as many as the national mean.

In addition, the brick blocks of a sidewalk cause a faulting and a wobble at the joint, a puddle at the time of the rainy weather by deterioration, and they obstruct the riding comfort for bicyclists and wheelchair users.

Therefore, the authors constructed barrier free designed works of the sidewalk and examined the effect, based on the basic policy of "Takamatsu City traffic barrier-free specific plan", : 1) barrier-free design of a Sidewalk based on the installation guideline to facilitate mobility on roads, 2) installation of the separating device for pedestrians and bicyclists based on the result of the social experiment, and 3) recycling of brick blocks of an existing sidewalk to color aggregates.

This paper gives a summary of the barrier free designed construction of a sidewalk and the effect acquired from a questionnaire and a traffic volume survey.

KEY WORDS: Barrier-free, sidewalk, pedestrian, brick block, questionnaire

1 INTRODUCTION

Center Street in Takamatsu City was remodeled in 1989 on the basis of "Center Street Promenade Project for Creative Takamatsu," which called for in-ground laying of electric wiring, brick block pavement, tree planting and modernized street illumination. Based on the opinions and recommendations of "Committee for Establishing and Promoting Specific Barrier Free Traffic Plan for Takamatsu City," the city authorities set out "Specific Barrier Free Traffic Plan for Takamatsu City," based on which the road administration authorities have put forward the barrier free road construction on Center Street and other street sections in Takamatsu City for the completion in 2010.

This barrier free remodeling project consisted of four phases as shown in Figure 1: Phase

1 started in the fiscal year 2006, Phase 2 and Phase 3 in the fiscal year 2007, and Phase 4 as a capping phase started in February 2008 and came to the completion in March 2009.

The main part of this paper will introduce the outline of that remodeling project based on the Specific Barrier Free Traffic Plan for Takamatsu City in which the sidewalk sections on National Highway Route 11 (a section between Takamatsu Chikko Station and Kuribayashi-cho) were remodeled as an accessible barrier free zone under the supervision by MLIT.

2 OUTLINE OF BARRIER FREE TRAFFIC PLAN

Prior to the start of the Barrier Free Work on Takamatsu Center Road, the road administration and the traffic control authorities in association launched the practical implementation according to the basic policy for the plan as shown in Figure 1.

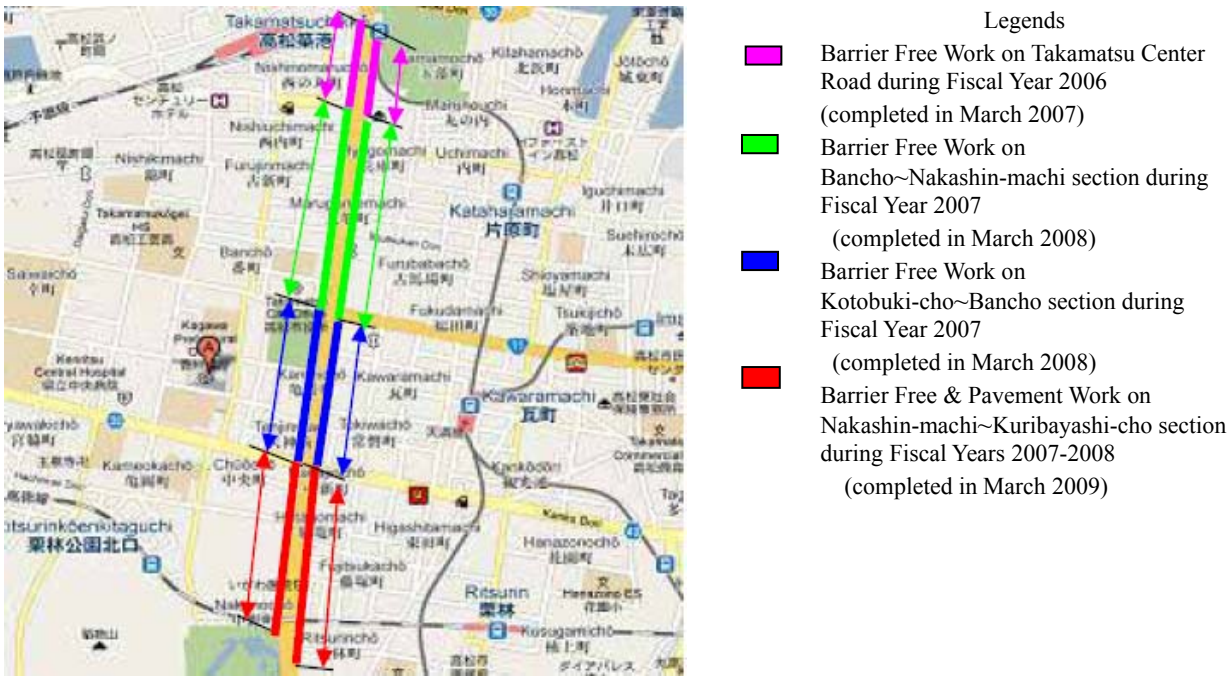


Figure 1: Route Map of Sidewalk Barrier Free Work

2.1 Barrier Free Improvement in Sidewalk based on Remodeling Guidelines for Smooth On-road Movements

In order to enable the aged, handicapped and other people to walk smoothly, the transverse slope was moderated from the previous 2% to 1% (see Figure 2) and the other provisions were also improved including the decrepit brick block pavements being replaced by new permeable asphalt pavements to improve the stepped and bumpy surface of sidewalks (see Photo 1). Also, a property line of a sidewalk and a vehicle roadway was made discernible by the aurally or visually handicapped and conforming to the universal designs (see Photo 2).

Table 1: Basic Policy for the Plan

Policy for Project Development	Previous Maintenance Standards and Road Conditions	New Development Policy
Barrier Free Remodeling based on "Remodeling Guidelines for Smooth On-road Movements"	● Transverse slope of pedestrian road at 2%; Road drainage by gravity flow	● To insure the compliance with the new legislative standards for the barrier free work, the transverse slope should be taken at 1% or below, and the longitudinal superelevation at 5% or below.
	● Appurtenant road components (CAB*, CCBOX**, curb, etc.) are provided in conformity with the transverse slope at 2%.	
	● Brick blocks were decrepit, and their joints were stepped and shaky, causing rainwater spatters and pools.	● The road pavements should be changed to permeable asphalt pavements.
	● A joining part (property line) of a pedestrian road and a vehicle roadway is unclear, especially for the visually handicapped.	● To assist them discern the line, the joining part should be stepped by raising 2 cm on the pedestrian road side.
Rearrangement of travel flow separation for bicycles and pedestrians on the basis of the social experiments.	● No separation barriers or markings are provided.	● Social experiments should be conducted on the traffic flow separation provisions (separation barriers and markings) to reflect citizens' voices. ● These provisions were studied on the site as to materials, coloring and others among the nation, the city and police, so that the visibility in night was assured.
	● There were no provisions for guiding the traffic flow around bus stops and safety devices.	● Traffic guide posts and other markings and safety railing should be provided to secure the safety of bus passengers.
	● There were no separation barriers between bicycles and pedestrians.	● For the safety of bicycles and pedestrians, their own dedicated travel zones should be provided in order to abate contact accidents and a feel of uneasiness. For this purpose: (1) the road surface should be color-coded, (2) the traffic flow should be separated by way of separation barriers and traffic control markings, and (3) separate flows should be prompted by way of travel guide posts and other markings.
	● There are road sections in which the sidewalk was as narrow as 3 m in width.	● Such a sidewalk space should be widened from 3 m to 4 m.

Note: * CCB is a box type of electric, telecommunication and gas distribution structure provided in ground.
** CCBOX is an improved type of CCB

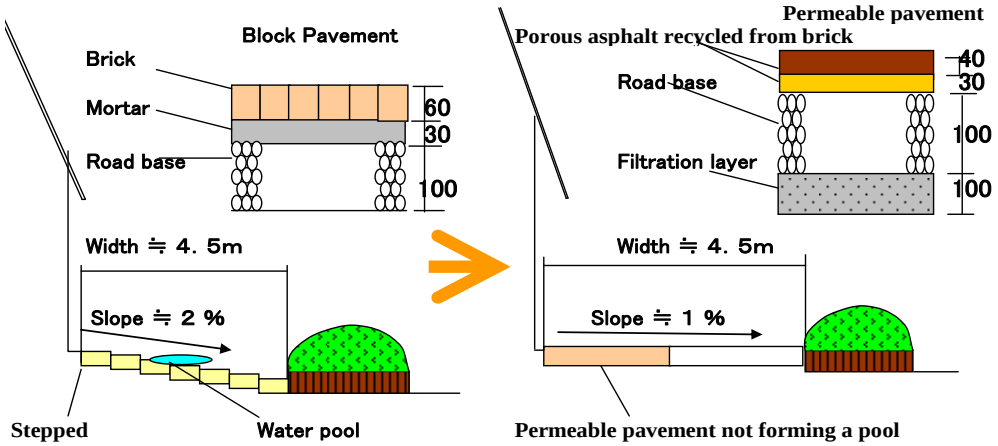


Figure 2: Sidewalk Sections before and after the Remodeling

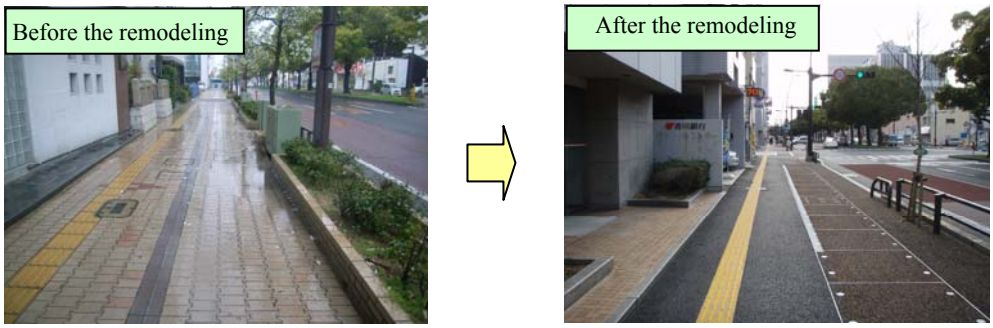


Photo 1: Sidewalk Surfaces before and after the Remodeling

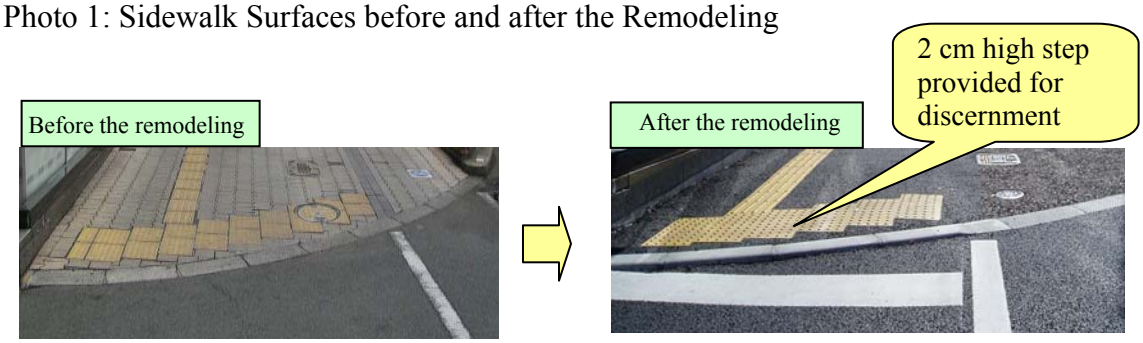


Photo 2: Stepped Property Line between Sidewalk and Vehicle Roadway

2.2 Separation Barriers and Markings for Bicycles and Pedestrians based on the Social Experiments

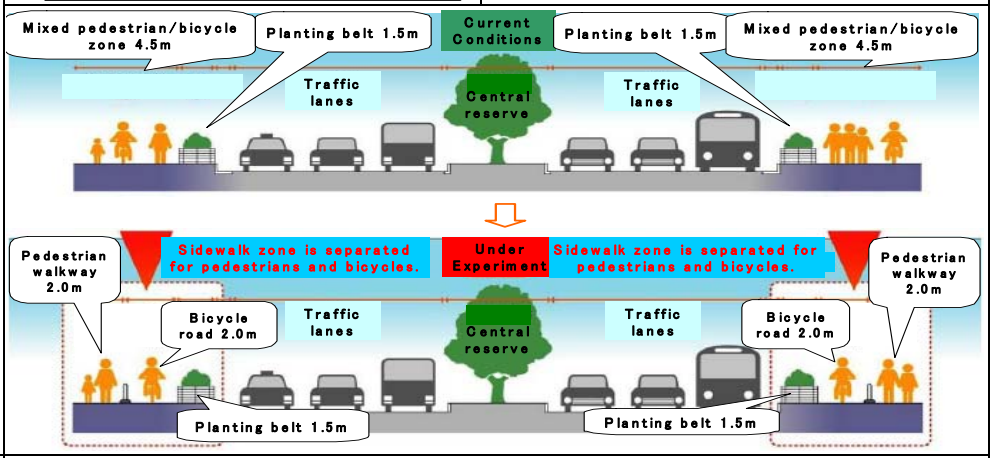
Though the bicycles have to travel on the left side of a vehicle roadway according to the traffic regulations, the fact is that a traveling space is not properly reserved for the bicycles, and that as nationwide behavior, the pedestrians and the bicycles usually travel on a sidewalk in a mixed-up mode imposing the danger of an accident.

In Kagawa Prefecture, the number of possessed bicycle is on the largest level. Particularly in Takamatsu City, the numbers of the possessors and bicycle accidents are two times larger than the national average.

In such a background, the social experiments were conducted for the separation of bicycles and pedestrians in order to secure a safe, comfortable travel space for both of them. The image of the experiments and the verification items are as shown in Table 2.

Table 2: Image of Experiments and Verification Items

<table>
<tr><td>Mode of verification</td><td>(1) Separation barriers only</td><td>(2) Separation Barriers and signboards</td></tr>
<tr><td>Image of the experiments</td><td colspan="2"> 


</td></tr>
<tr><td rowspan="8">Verification items</td><td colspan="2">● How have the travel frequencies been changed between (1) and (2) above?</td></tr>
<tr><td colspan="2">● Traveler’s view</td></tr>
<tr><td colspan="2">● Traveler’s pros and cons</td></tr>
<tr><td colspan="2">● How easily the travelers have recognized the separation of their space?</td></tr>
<tr><td colspan="2">● How easily the signs can be recognized and understood in terms of their height and design?</td></tr>
<tr><td colspan="2">● Safety by the separation barrier and markings</td></tr>
<tr><td colspan="2">● Design, materials, color, etc. of the separation barrier and markings</td></tr>
<tr><td colspan="2">● How effectively the traveler’s behavior is changed by the barriers and markings?</td></tr>
</table>

The citizen’s views gained through the social experiments were reflected upon the size, shape and structural system of the separation barriers and markings. All these barriers and markings were made to be highly discernible and to absorb a shock in case of contact and yet designed to be agreeable to the townscape. These barriers are of rigid construction, but have a rubber base. (see Photo 3).

According to the experiments, the citizens acknowledged the barriers to distinctively separate a sidewalk, based on which a pipe section barrier was made to be 70 cm long and installed at five meter intervals on a separating white line to appeal the pedestrians and bicycles.

In addition to the separation barriers, a 1.2 m high guidepost was provided at each end of a sidewalk section and both sides of cross-roads. The existing 4.5 m wide sidewalk was divided to two parts of an equal width of 2.25 m as a basic module. Also, in the road section from Nakashin-machi to Kuribayashi Park, the previous above-ground planting boxes used for street trees and planting were removed, and trees were planted in an in-ground sunken type box to increase the width of a sidewalk, and railing type of traffic barriers were provided on the side of a vehicle roadway for the safety of pedestrians (see Photo 4, 5 and 6).

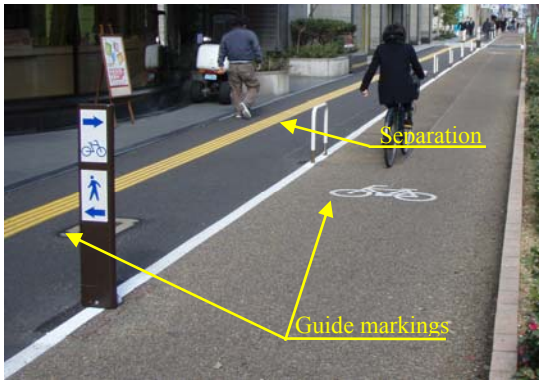


Photo 3: Separation Barrier and Traffic Sign

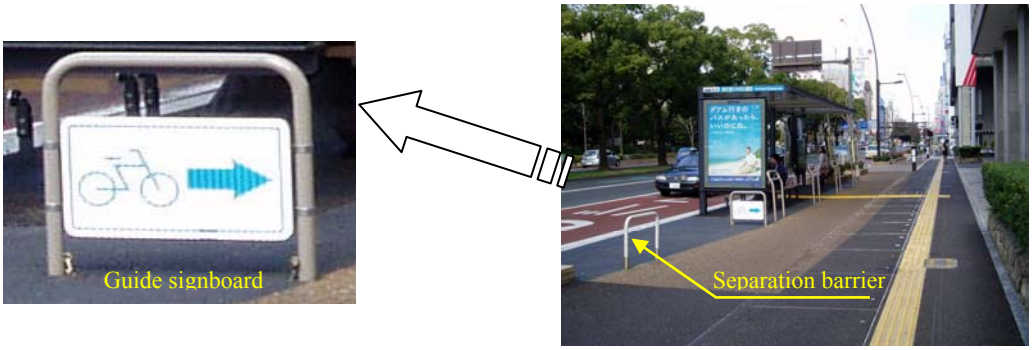


Photo 4: Separation Barrier and Guide Signboard around a Bus Stop

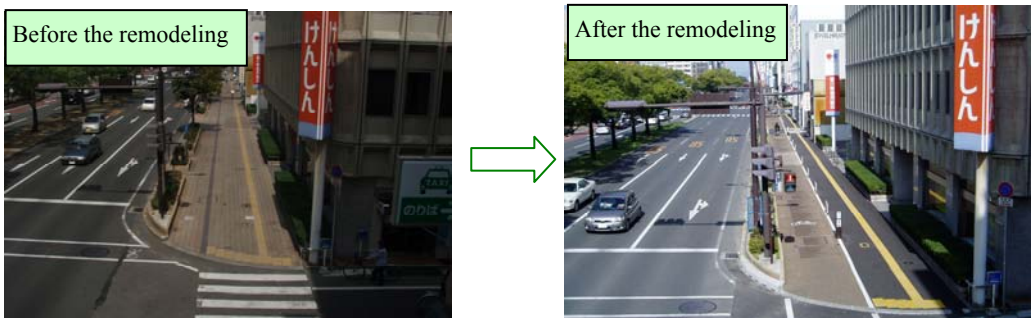


Photo 5: Zone Separation for Bicycles and Pedestrians (Kotobuki-cho~Nakashin-machi)

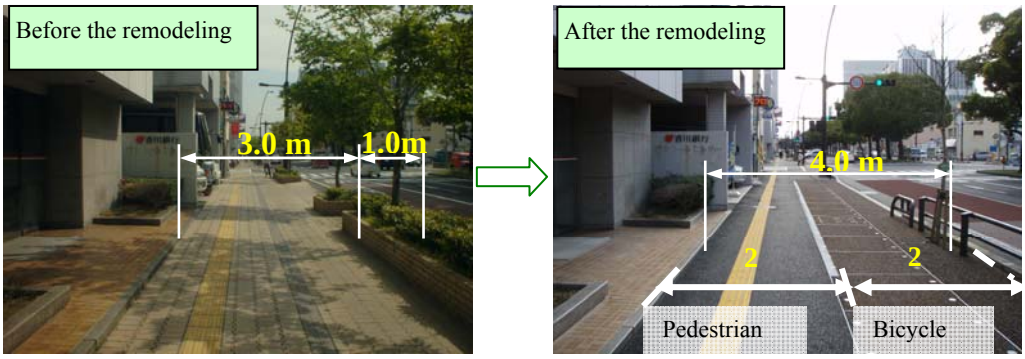


Photo 6: Increased Pedestrians Zone (Nakashin-machi~Kuribayashi Park)

3 CONTRIVANCE IN THE REMODELING AND FLOW OF CONSTRUCTION WORK

The present remodeling road sections were paved with brick blocks on the occasion of the underground utility laying work (CAB work) in 1987. Thereafter, as time passes, the joints of blocks have been stepped and bumpy, hampering the smooth travel by a bicycle or wheeled chair, and broken at vehicle entrances. It was considered very effective in the environmental policy and cost saving if brick blocks are crushed to pieces and used as colored aggregates for patterned pavements. For this purpose, studies were made to confirm such an idea in a practical aspect. Upon the finding of the practicability through experiments, Center Street in Takamatsu was dismantled of its brick blocks. They were collected in an asphalt plant where they were broken and screened out at its associated treatment plant as coarse aggregates (5 to 13 mm dia.) for use in permeable asphalt mixture.

3.1 Problematic Issues encountered in Phase 1 Construction and Countermeasures

The Phase 1 construction (Year 2006) was performed in a groping way. The working people took any problematic issues encountered in this phase to the advantage of the succeeding phases by finding an appropriate solution. Those problematic issues encountered and the improvement solutions are as shown in Table 3.

Table 3: Problematic Issues and Improvement Measures

Problematic issues in Phase 1	Improvement Measures in Phase 2 et seq.
(1) By using a petroleum resin binder, common aggregates were used in the pedestrian zone and colored ones in the bicycle zone; however, the binder's light brown had come out too strongly to differentiate these separate zones.	(1) In lieu of the petroleum binder, modified polymer asphalt type II was used, and the road surface in the bicycle zone was treated with water jet to expose the colored aggregates. The road surface was clearly color-coded and yet showed a natural, stable tone of color beyond that obtainable by a staining agent.
(2) The pavement work became laborious due to the different mixtures used for the pedestrian zone and bicycle zone.	(2) The mixtures for these zones were unified, enabling both of zones to be worked out in the entire width of a sidewalk. Thus, the working ability was improved.
(3) The asphalt mixtures became expensive due to the use of expensive petroleum resin binder.	(3) The use of modified polymer asphalt type II contributed to a lowered price of mixture and became economical if the water jet expense was included.
(4) The construction required a longer time and higher cost due to a epoxy resin mixture being used on the cover layer of the CAB.	(4) Instead of the epoxy resin, the same type of modified asphalt mixture as in (1) above was used.
(5) The colored aggregate comprised three parts yellow chart and seven parts reclaimed brick. To provide against abrasion and cracks in the future, a resin topcoat was applied on the surface of vehicle access and bicycle zone to increase the surface strength, eventually leading to a cost increase.	(5) The colored aggregate comprised eight parts yellow chart and two parts reclaimed brick by decreasing the reclaimed brick to rely on the strength of common aggregates. The surface coating was limited to vehicle access portions. Also, for strengthening of the surface, permeable type resin mortar filling method (hereafter "PRMS Method") was employed (with mixing ratios of aggregates taken as one part red, one part yellow and one part white) for improved color identification.

3.2 Flow of Construction Work

The sequence of construction procedures was taken as follows in Phase 2 and succeeding ones.

1) Removal of Paved Brick Blocks and their Reclamation

The removed and collected brick blocks were crushed and screened out at the treatment plant as part of an asphalt plant for use as coarse aggregates (5 to 13 mm) for permeable asphalt

mixture, thus being recycled. Figure 3 shows a road profile of the pavements having existed before the remodeling work.

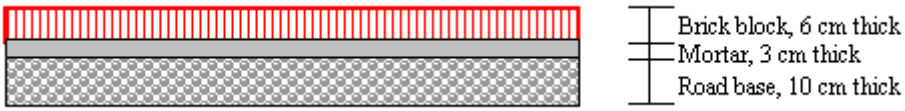


Figure 3: Road Profile of the Previous Pavements

The removal condition of the previous brick blocks is as shown in Photo 7, and the crushed and reclaimed brick aggregates at the treatment plant are as shown in Photo 8.

Photo 7: Removal Condition of the Previous Brick Blocks

Photo 8: Reclaimed Brick Aggregates (5-13 mm)

2) Excavation, Filter Layer, Road Base and Base Course Work

The remodeling construction was performed in the following sequence: excavation performed down to the required level; filter layer (sand) laid; road base (reclaimed aggregates) constructed; permeable asphalt mixture as base course rolled out by a mini asphalt finisher. The construction profile is as shown in Figure 4.

Figure 4: Construction Profile

Photo 9: Laying of Surface Course (Rolling and Compacting)

3) Surface Course Work

In the same way as for the base course, the porous asphalt mixture with reclaimed-brick was rolled out by a mini asphalt finisher. Based on the result of Phase 1 work, the composition of

the color aggregates was changed to eight parts yellow chart and two parts reclaimed brick aggregates in order to improve the durability. The surface course installation is as shown in Photo 9.

4) Aggregate Exposure Work (Water Jet Treatment)

On the bicycle zone, the pavement surface was treated by water jet operation to expose the aggregates and show a natural tone of aggregate color. The water jet operation is shown in Photo 10, and the exposure condition of the surface after the water jet treatment is shown in Photo 11.

Photo 10: Water Jet Operation

Photo 11: Exposure Condition of the Surface after the Water Jet Treatment

5) Surface Strengthening Treatment

The PRMS Method was employed to strengthen the surface portion for a vehicle access. In this method, red, yellow and white ceramic aggregates were mixed in a proportion of 1:1:1 respectively to obtain a bright tone for enhanced visibility. The surface finishing operation is shown in Photo 12, and the appearance of a finished surface is shown in Photo 13.

Photo 12: Surface Finishing Operation

Photo 13: Appearance of Finished Surface

4 EFFECTS OF THE REMODELING

A survey study was made by way of questionnaires and observation of travel conditions to know the results of the zone separation and the separation barriers and markings provided in the section of Center Street, Takamatsu City. The results are as shown in Figure 5 and 6.

On a safety aspect, 74% of the people who answered the questionnaire felt that the safety was improved. Also, the collateral effects were found regarding an improved manner of travellers, a feel of safety in the travel and an atmosphere of amenity. As for the observance of zone separation, traveling conditions of pedestrians and bicycles were observed two months after the installation of the separation barriers and markings. Both of pedestrians and bicycles were found to follow the separation rule at 90% in observation ratio and same ratio for the

bicycles increased by 50% as compared with that found before the remodeling.

In addition, 25% of the people answered that they became learned the zone separation rule applicable to the pedestrians and bicycles and that they became thought about the traveling manner about bicycles and pedestrians, thus noticeably deepening their awareness of sidewalk use. In this way, the remodeling has brought remarkable effects for the people.

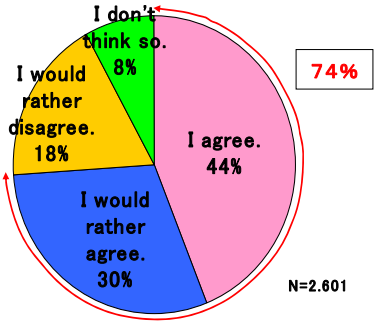


Figure 5: Answers to the questionnaire

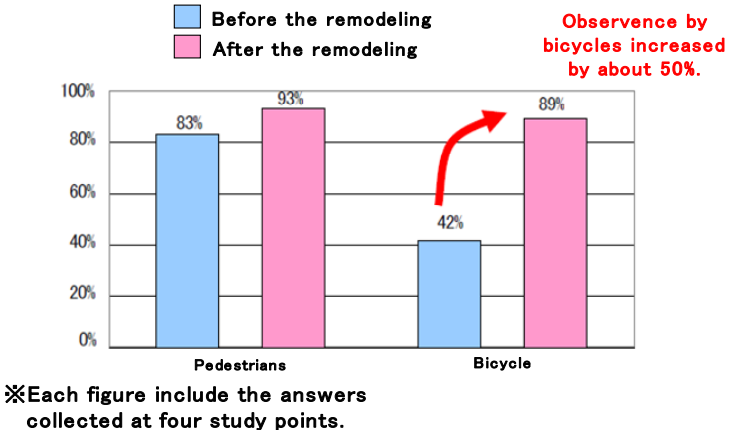


Figure 6 : Observance Ratios of Zone Separation (based on the travel study)

5 CONCLUDING REMARKS

Started in the fiscal year 2006, the Barrier Free Remodeling Project for Center Street, Takamatsu City has been completed in March 2009 in all four phases. The project has brought such effects as summarized below.

1) In line with the Remodeling Guidelines for Smooth On-road Movements, the sidewalk with the barrier free arrangement and the traffic markings adapted to the universal design has been realized by way of the moderated transverse slope, steps and bumps being smoothed, and the property line between a sidewalk and a vehicle roadway being made discernable to the visually handicapped.
2) By reflecting the opinions of the sidewalk users through the social experiments, the travel zone was separated by the barriers and markings to the dedicated pedestrian zone and bicycle zone. As a result, it was found through the questionnaire study that such separation has been contributing not only to the preventing of contact accidents but also to improvement of pedestrian manners, which fact adds to the securing of a safe, comfortable pedestrian space.
3) When the pavement bricks were crushed and reclaimed for use as aggregates, those aggregates could not only reduce the environment loads but also be utilized as color aggregates for the enhanced townscape.
4) After the completion of Phase 1 construction, the problematic issues encountered in this phase were straightened for the future improvements in design, material arrangement and construction method in Phase 2 and succeeding ones. In consequence, the visibility of sidewalk pavements and quality-related properties of completed construction have been largely improved and the costs also reduced by about 16%.

Lastly, on the basis of the useful knowledge and experience obtained on this project, we will continue every effort to realize an effective use of bicycles in an urban area and a safe, comfortable travel space even to the aged and the handicapped people.