The pavement plan for the New Tomei Expressway

N.Wada, Y.Tsukiyama, T.Yanagisawa & T.Oka
Central Nippon Expressway Co., Ltd, Tokyo, Japan

ABSTRACT: The New Tomei Expressway, which will link Nagoya to Tokyo, is now under construction for the partial opening in 2012. Composite pavement consisting of concrete as the lower layer and asphalt as the upper layer is applied to the pavement in the cut, embankment and tunnel sections, because the pavement is superior to asphalt pavement on durability, the life-cycle cost and securing good driving comfort in the long term. This paper introduces the pavement plan of the New Tomei Expressway.

KEY WORDS: The New Tomei expressway, composite pavement

1 INTRODUCTION

It has passed approximately 45 years since the first expressway was constructed in Japan. The total length of expressways has been extending and reached to approximately 8,555km. Asphalt pavement, easily constructed and maintained, has been used as the expressway pavement and currently accounts for more than 90% of total. Porous asphalt pavement, which can drain and reduce noise, has been applied to surface course since 1998. The open graded asphalt pavement, securing good driving comfort for passengers in vehicles especially in rain, is used for approximately 70% of the asphalt pavement.

However, many pavement distresses have been currently noticed on the decrepit asphalt pavement. It is necessary to repair not only surface course and binder course but also base course under the binder course. The repair works which need traffic regulations and possibly cause traffic jams have difficulty in being adequately done in the heavy traffic expressways. In addition, the consideration of the Life-cycle cost needs the durable pavement.

Therefore, composite pavement, which is more durable than asphalt pavement, will be applied to the pavement of the cut, embankment and tunnel sections in the New Tomei Expressway under construction. Both porous asphalt pavement and water proofing layer will be, on the other hand, applied to the pavement of the bridge sections.

In this paper, we report on the pavement plan for the New Tomei Expressway.

2 OUTLINE OF THE NEW TOMEI EXPRESSWAY

2.1 Location and objective

Figure 1 shows the route of the New Tomei/ New Meishin Expressway. The New Tomei/ New Meishin Expressway is the expressway linking Tokyo to Osaka with its length of about 504 km. 98 km of the expressway has already been in operation. The New Tomei expressway will be constructed alongside the existing Tomei Expressway, which is an arterial expressway, and link Tokyo to Nagoya with its length of about 255 km. The expressway, passing one of the most prosperous areas in Japan, will be a heavy traffic beltway.

The objectives of the expressway are as follows:

1. The radical improvement of the service provided by the existing Tomei expressway
2. The improvement of the reliability of the Expressway network
3. Closer ties of three metropolitan areas such as Tokyo, Nagoya and Osaka

The New Tomei expressway will be opened in sections starting with the section between Gotemba JCT. and Inasa JCT. in 2012.

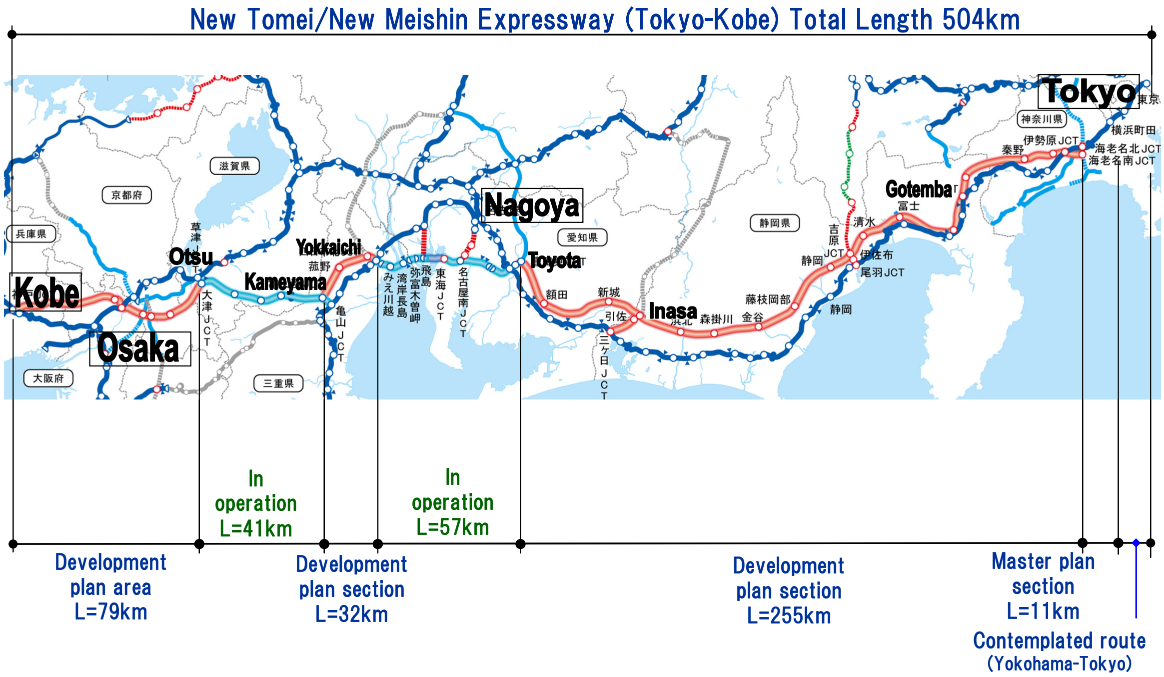

Figure 1: The route of the New Tomei/New Meishin Expressway

2.2 Geography

Japan is not only a country consisting of many islands but also a mountainous country, where approximately 70% of its land is covered with mountain. In addition, approximately 120 million people, which is 1/2 of the population in the U.S., live in the small land, which is 1/25 of the land of the U.S.. The population density is therefore quite high in the small plains.

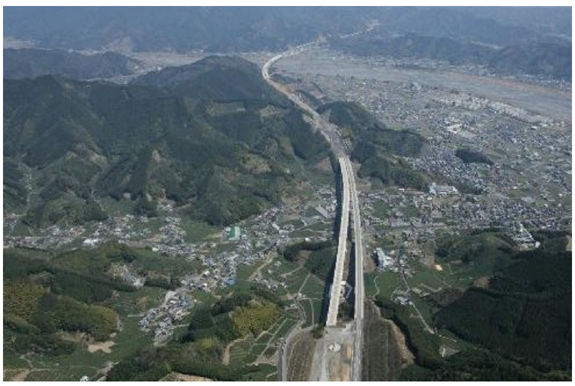

Figure 2: Aerial photo of the New Tomei expressway

The most part of the New Tomei is located in the mountainous areas in order to avoid the highly populated plains along the Pacific Ocean. The expressway therefore consists of many bridges and tunnels. The bridge sections account for approximately 31% of the total length, while the tunnel sections account for approximately 26%. The soft ground and disintegrated rocks make it difficult to construct the cut, embankment and tunnel. The expressway passes across the main rivers such as Fuji river, Ooi river and Tenryu river.

2.3 Cross section

Concerning the number of lanes, the tentative 4 lane system is constructed at first. In the future, however, this is planed to be expanded to a total of 6 lanes. The expressway, highly designed compared to the existing expressways, will increase the traffic capacity of the sections between Tokyo and Nagoya and alleviate traffic jams caused by not only traffic concentrations but also traffic accidents and maintenance.

2.4 Geometric characteristics

Table 1 shows the geometric characteristics of two expressways. From the geometrical point of view, the New Tomei Expressway surpasses the existing Tomei Expressway even though the expressway is located in mountainous areas. The improvement of the geometrical characteristics will decrease the travel time and make the effectiveness of the expressway network higher. Once the New Tomei/ New Meishin expressway is completed, the travel time between Tokyo and Osaka will be reduced by a total of 1 hour to approximately 5 hours.

Table 1: Geometric characteristics

	Existing Tomei	New Tomei
Design speed	100km/h	120km/h
Min. Curve radius	300m	1,500m
Max. slope gradient	5%	2%

2.5 Projected traffic volume

Table 2 shows the projected traffic volume of the New Tomei Expressway. It is certain that commercial vehicles, accounting for approximately 50% of the total traffic volume, have an effect on the durability of the pavement.

Table 2: Projected traffic volume

	Gotemba JCT. - Inasa JCT.
Total traffic volume [vehicles/day]	44,700-60,000
Commercial vehicles volume [vehicles/day]	21,600-32,700
Commercial vehicles ratio [%]	48-58

3. THE PAVEMENT PLAN FOR THE NEW TOMEI EXPRESSWAY

3.1 The pavement type

Composite pavement is applied to the pavement of the New Tomei expressway between Gotemba JCT. and Inasa JCT.. Composite pavement is a pavement consisting of surface course, intermediate layer, continuously reinforced concrete slab and cement-stabilized base course. Continuously reinforced concrete (CRC) slab is adopted due to the comfortableness coming from fewer joints and the prevention of reflection cracks.

Table 3 shows the details of asphalt pavement, concrete pavement and composite pavement. The asphalt pavement, mostly used for expressway pavements, has the advantage of the initial cost, quietness, the easiness of maintenance. However, the design period of the pavement, which is about 10 years, is shorter than the others'. Concrete pavement, on the other hand, has the opposite characteristics from the same point of view. Composite pavement has a pavement which has the advantages of both asphalt pavement and concrete pavement. Concerning the life-cycle cost of both composite pavement and asphalt pavement, the initial cost of the composite pavement is higher than the asphalt pavement'. The life-cycle cost of the composite pavement is, however, almost the same as the asphalt pavement' due to the cheapness of maintenance cost such as cutting and overlay.

Composite pavement is therefore applied to the pavement for the New Tomei expressway.

Table 3: Comparison of pavement types

Items	Asphalt pavement	Concrete pavement	Composite pavement
Design period	The standard design period is ten years.	The standard design period is twenty years.	In the case of New Tomei, the standard design period is forty years.
Deformation/wear resistance	This type is more prone to wearing, rutting and ravelling, etc.	This type is not prone to rutting and less prone to other distresses.	Compared to asphalt pavement, this type is less prone to rutting and other distresses.
Noise and vibration	This type generates lower levels of noise and vibration.	In some cases, noise and vibration can be problems.	This type generates lower levels of noise and vibration.
Serviceability	Maintenance and repair work can be done relatively easy using cutting and overlay techniques.	Reconstruction of concrete slabs is more difficult than the asphalt pavement.	Maintenance and repair work can be done relatively easy using cutting and overlay techniques.

3.2 Pavement plan of cut, embankment and tunnel sections

Figure 3 shows the planned composition of the composite pavement. The composite pavement has a 4 cm-thick surface course, a 4 cm-thick intermediate layer, a 24 - 28 cm-thick continuously reinforced concrete slab and a 20 cm-thick base course, yielding a total pavement thickness of about 52 – 56 cm. For the intermediate layer, the Stone Mastic Asphalt (SMA), is to serve as a waterproofing layer, is adopted.

Figure 4 shows the cross section of a hybrid pavement, used as the surface course in the tunnel section. The hybrid pavement with the intermediate function of both porous asphalt and SMA is superior to the porous asphalt on the durability and the resistance to raveling. The hybrid pavement is however inferior to the porous asphalt on the drainage function and noise reduction. The hybrid pavement therefore is adopted only for the surface course in the tunnel section, where the drainage function is not necessary.

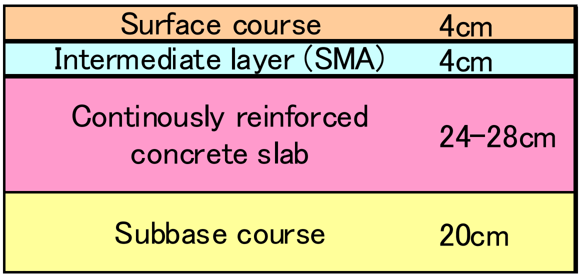

Figure 3: Composition of Composite pavement

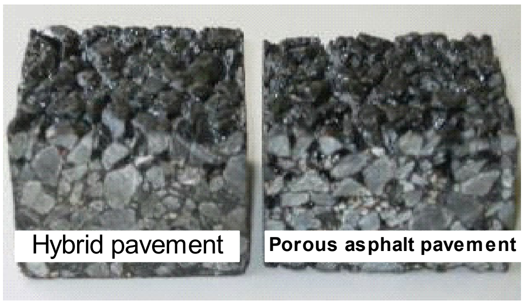

Figure 4: Hybrid pavement

Figure 5 shows the design chart for the thickness of the CRC slabs. This design chart is determined based on the theoretical analysis and the examples of foreign countries. The thickness of the CRC slabs, determined by the cumulative commercial vehicles in 40 years, is 28 cm in the cut and embankment section, and 24cm in the tunnel section.

Figure 6 shows the sketch of the slip-form pavement to build CRC slabs. The slip-form paving is the paving method using the self-propelled vehicles equipped with a compacting device and a forming device to continuously cast concrete slabs. With this method, forms and rails for construction machinery to travel on in the conventional setform paving method can be omitted.

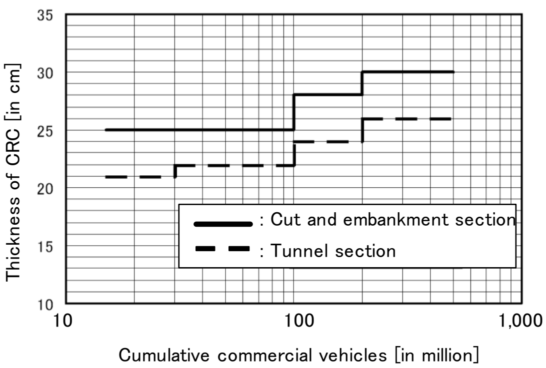

Figure 5: Design chart for the thickness of the CRC slabs

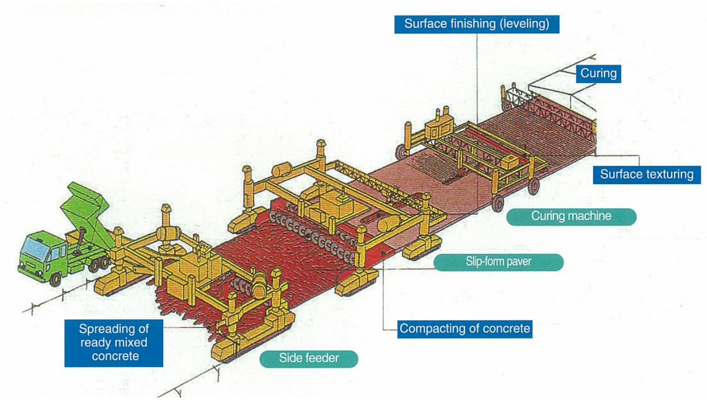

Figure 6: Slip-form pavement

3.3 Pavement plan of special sections

The composite pavement is a superior pavement; however, the pavement should not be applied or should be reinforced in some special sections.

Table 4 shows the details of special sections. The composite pavement has difficulty in following the subsidence possibly occurring in the sections where loam is used as embankment material and where embankment is on soft ground.

In these sections, asphalt pavement, which is more flexible to the subsidence, is therefore applied.

Table 4: Details of special sections

Special section	Reason	Asphalt pavement	Composite pavement
Sections where loam is used as embankment material	There is a possibility of embankment subsidence.	○	×
Sections on soft ground	There is a possibility of embankment subsidence.	○	×
Transition of cut and embankment	There is a possibility of embankment subsidence or nonuniform settlement.	○	Should be reinforced
Highly embankment sections	There is a possibility of residual settlement.	○	Should be reinforced

The structure of asphalt pavement is determined by the TA method, which is one of the empirical methods based on the results obtained from the AASHO road tests and various surveys. Figure 7 shows the design curve used to determine the structure. Figure 8 shows the cross section of the asphalt pavement, which has been a standard composition of expressway pavements in Japan since 1970’s. For the surface course, porous asphalt is adopted.

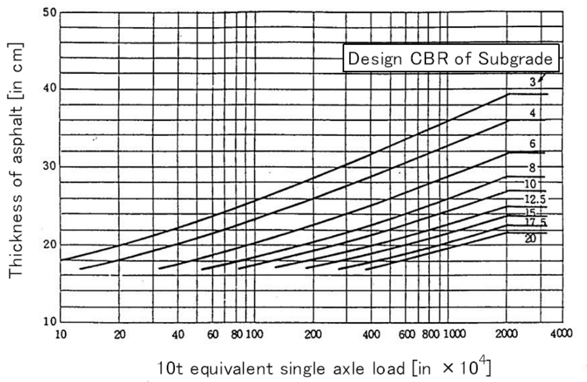

Figure 7: Design curve of asphalt pavement

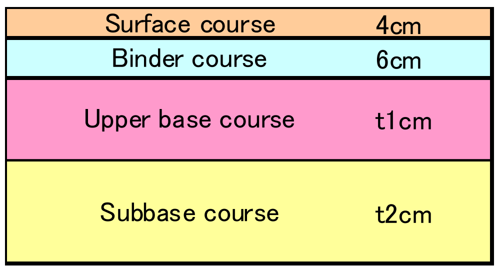

Figure 8: Composition of asphalt pavement

3.4 Pavement plan of the bridge section

Figure 9 shows the cross section of the pavement in the bridge section. On the concrete slabs, porous asphalt pavement is applied to the surface course, and SMA, which is waterproof, is applied to the leveling layer. In addition, waterproofing layer, affecting the life of a bridge, is applied on the concrete slabs. In the next chapter, we will take up the details of the waterproofing layer in more detail.

On the steel plate deck, Guss asphalt is, on the other hand, applied as a waterproofing layer as shown in Figure 10.

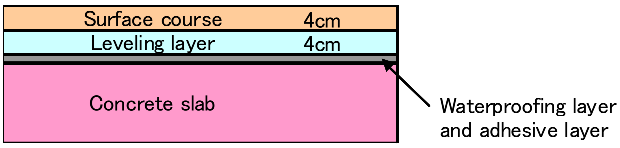

Figure 9: Composition of pavement on concrete slabs

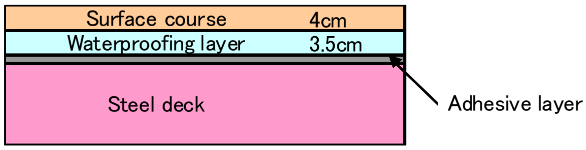

Figure 10: Composition of pavement on steel decks

3.5 Waterproofing layer

Waterproofing layer is the layer which prevents rainwater and the Chloride of antifreeze agent from entering the slabs, delaying the rust of Re-bar in the slabs. The layer thus improves the durability of the concrete slabs. There are two types of waterproofing, a coated type-waterproofing layer composed of resin coat in a single layer, and a sheet type waterproofing layer composed of an unwoven fabric of long polyester impregnated with modified asphalt. Waterproof layer in the harsh condition has some examination such as tensile strength test and shear test as well as waterproof test and the Chloride insulation test, thus controlling the quality.

4. THE CONSTRUCTION OF THE PAVEMENT

4.1 The adoption of cutting-edge technologies

We are going to introduce three examples of the adoption of cutting-edge technologies. First, figure 11 shows the semi-automatic slip-form paving with total station. The total station automatically detects the prisms on the slip-form paver. The mold and steering of the slip-form paver are automatically controlled based on the data from the total station. In addition, the total station measures the constructed CRC slabs and then feedbacks the measured data to the paver. Thus, the accuracy of the CRC slabs' shape such as the surface evenness is improved.

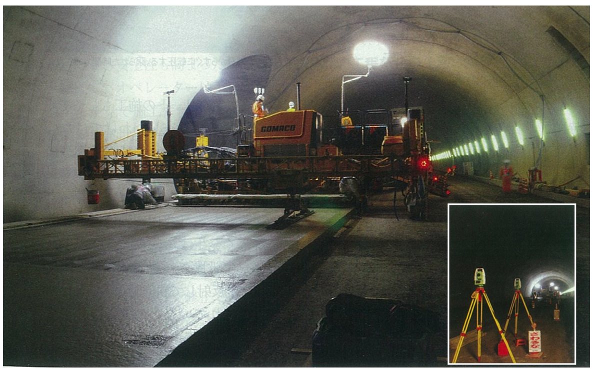

Figure 11: Semi-automatic slip-form paving

Second, the compaction of paving mixture with GPS is adopted in some sections. The operator of the compacting equipments such as a macadam roller and a pneumatic-tired roller can make a compaction while watching the display on which the number of compaction is displayed, ensuring the compaction of the paving mixture.

Third, warm mix asphalt is applied to some sections. The warm mix asphalt is the asphalt with microscopic bubbles produced by special admixture, decreasing the mixing temperature. This technology reduces the fuel consumption of the mixture, resulting in the decrease of the CO_2 emission.

4.2 Present condition

As of December 2009, most of the pavement works are preparing for the construction of the cement-stabilized subbase course. The CRC slabs in some tunnel sections have already been completed. In the trial course in Kakegawa, surface course has already been completed. The quality of the CRC slabs in both sections is adequate.

5. ACKNOWLEDGEMENTS

We would like to thank the Paving companies, Nippon Expressway Research Institute Company Limited, The construction offices of Tokyo branch of Central Nippon Expressway Company Limited, The construction bureau of Tokyo branch of Central Nippon Expressway Company Limited.

REFERENCES

Central Nippon Expressway Company Limited. ：*Design manual vol.1*

Central Nippon Expressway Company Limited. and Expressway technology Center ： *Pavement design manual of The New Tomei expressway*

Expressway technology Center ：*Expressway Pavements in Japan*