LARGE ROAD-SURFACE PICTURES DRAWN WITH THE TILE COMPOSITE CONCRETE BLOCKS (ILB EXCEED) ON THE ROADS IN THE RESORT

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SUMMARY

In June of 1987, as the result of the joining of six ministries (Ministry of Agriculture and Fisheries, Ministry International of Trade and Industry, Transport Ministry, Construction Ministry, Self-Government Ministry) centered around the National Land Ministry, the "General Recreation Area Outfitting Act (Resort Act) was enacted for the overall development and outfitting of large scale resorts aimed at activating regional vitality and expansion of domestic demand and permitting diverse leisure activities, through the introduction of private vitality.

Here we will introduce the outfitting plan for the Chichibu resort area which was approved under the Resort Act in March of 1989 and which was developed and promoted on a large scale including one city, six towns and four villages in the Chichibu area of Saitama Prefecture located in a zone some seventy kilometers to the northwest of the capital, Tokyo. The symbol facility representing this plan is the access garden road (referred to as the Sky Road) extending as much as 18 meters in width and 4 kilometers in length which links the summit of the mountain ridge from north to south.

Tile composite concrete block (product name: ILB EXCEED) was adopted for the entire surface as the pavement material for this Sky Road. Furthermore, using this product, we have presented an extensive road surface sketch on a scale un-paralleled anywhere in the world, through the development of a design that adopts the theme of "the creation of a universe" into a pavement surface.

This paper reports on the outline of the execution of the work for the Sky Road and its pavement that makes use of interlocking blocks of composite tiles (hereafter referred to as ILB EXCEED)

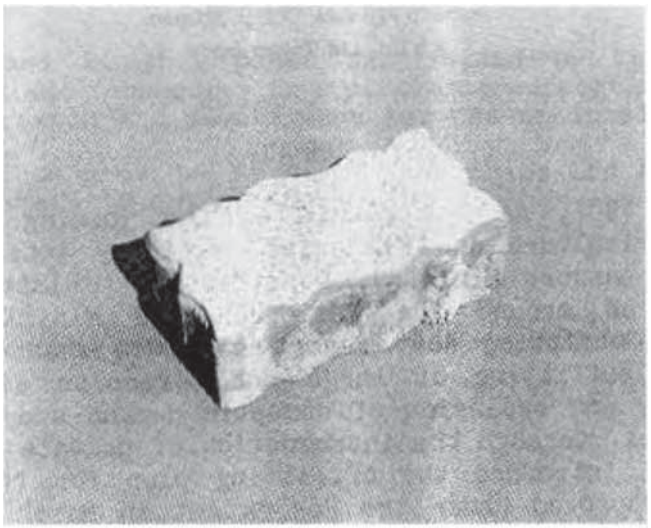
1. ILB EXCEED

1-1 What is ILB EXCEED?

ILB EXCEED is a pavement material that combines the design characteristics and material texture possessed by floor tiles, the interlocking effect and laying characteristics possessed by interlocking blocks.

The structure of the blocks is formed into a uniform structure by adhering the 9 mm thick ceramic quality tile onto a plate shaped base block using a special mortar (See Photograph-1). The adhesion is done while applying a strong vibration compaction to the tile for 5-6 seconds using our own originally developed compounding device.

In addition, the tile is made somewhat smaller than the plate shaped base block and a counterfort is established to prevent the corners from deflecting due to the traffic load.



Photograph-1 ILB EXCEED

1-2 Special features

ILB EXCEED is a pavement material which is suitable for a wide variety of applications and that exhibits a novel road surface with a high class sensation through the combination of the functions respectively possessed by conventional floor tiles and interlocking pavement featuring the following characteristics.

1) Possesses the high design property of tile (luster and quality feel).
2) Since it is a dry type construction method that does not use mortar it can be released to traffic immediately following execution of work.
3) Since specialized knowledge, such as for floor tiles, is not required the construction period can be reduced.
h) Since the expansion of the tiles and concrete due to heat rises in summertime is absorbed by the Joints, cracking of the tiles due to blow-up does not occur.
5) For this reason, it is not necessary to install expansion Joints which may easily damage the design characteristics, such as for tile pavement.
6) Execution is simple and maintenance can easily be done by partial removal and replacement.
7) It possess high strength and wear resistance, offers strong resistance to the effects of weather and is not slippery.

Moreover, it offers high adhesive strength due to vibration and pressurization methods using special mortar, thus eliminating stripping and similar problems.

2. The Resort Area Outfitting Concept for the Chichibu Region of Laitarna Prefecture

2-1 Introduction of Chichibu Muse Park

A special feature of Chichibu Resort is that it aims at the formation of a cultural resort area that highlights the local festivals and culture that are peculiar to the Chichibu area under the theme of "sensitivity and sympathy."

The Chichibu Muse Park, that boasts a ground area covering 375 hectares and which is currently being constructed, will become the base for this Chichibu resort and should play the role as the overall leading project of the development.

This Chichibu Park will be composed of three large zones, the Culture Grove, the Center Zone and the Sports Grove running from the north of the mountain ridge over a long ground area extending about 4 kilometers from north to south. Here, the installation of all sorts of sports facilities, music and cultural facilities, amusement facilities, hotels and the like is being planned. In addition to these, is the Sky Road by ILB EXCEED that will integrate and link the three zones.

2-2 Positioning of Sky Road

Sky Road is an access garden road attaining a width of 18 meters and a length of about 4 kilo-meters that runs north to south along the summit of the mountain ridge and is the symbol facility representing Muse Park from which one can appreciate its dynamic scenes and sense of scale.

This Sky Road is positioned as a road which will encompass such road potential as the framework space of Muse Park, the symbol space, traffic space, and the space for the creation of event exhibits and new sports as well.

3. Outline of Skv Road

3-1 Construction Project Outline

1) Application: Promenade
2) Width: 18 m
3) Length: about 4 km
4) Horizontal alignment:
   Sky Road is an aerial passageway that was designed incorporating the gentle undulations of the Chichibu region, just as they are, where the profile of the road faces the sky. It is curving and winding in ten areas and undulating in 7~ 10% of its total area.
5) Configuration and laying pattern of the ILB that was used:
   The work employed blocks of a rectangular shape (Figure-1), the most typical configuration, which offers the most diverse laying patterns, and the widest design development, together with herring bond which offers an outstanding load distribution effect.

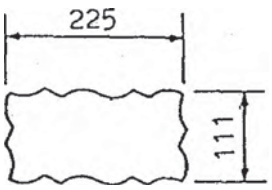


Figure-1 Rectangular type configuration

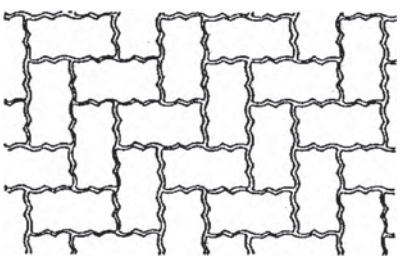


Figure-2 Herring bone bond

6) Color scheme:
In depicting the large scale major road surface sketch, we used a total of 21 colors such as white type, gray type, brown type, olive type, beige type, pink type, gray type and special order colors in order to provide a balanced coloring sensation.

3-2 Design concept

The orientation for the creation of the Sky Road design was found by expanding the image toward the sky, the atmosphere, the universe, etc., that are associated with a road that runs along a mountain ridge.

The content represents the "design of the theme of creation of a universe (life approach) which develops the process from the "birth of the quark (the original atom) prior to the birth of the universe to the "big bang that gave birth to the universe, " "birth of life" and the "birth of human beings."

In particular, a design of 50 meters in diameter projecting the image of the big bang, the phenomenal event that gave rise to the universe is being considered such that it will become the focal point of the roughly h kilometer long road. (See Photograph-2.)

This extensive road surface sketch will touch upon the history up to the dawning of mankind and also attempt to provide proof of harmony with environment that it is, the nature, seasons and traditions possessed by the Chichibu region and the working of human beings and thus present a road surface to which persons will respond.

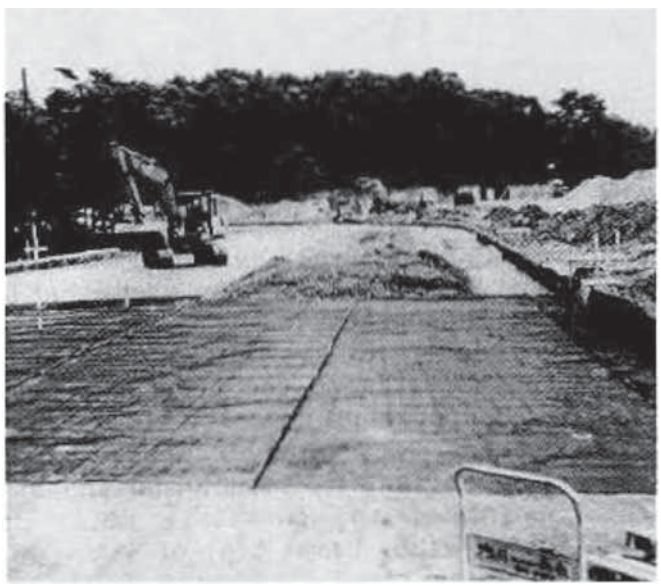


Photograph-2 Big bang of Sky Load

3-3 Countermeasures Against Settlement due to Consolidation of the Embankment Subgrade Surface and Pavement structure

1) Countermeasure for Settlement due to Consolidation of the Embankment Road Floor

Tha subgrade soil of the said site is composed of high moisture content clay matter and is continuously composed of cut-embankment soil. Moreover, there is concern over possible settlement and cracking of the pavement due to faulting and settlement due to consolidation in the vicinity of the cut and the embankment following the completion of the ILB EXCEED pavement, due to the rapid execution of the work for the pavement section. Hence, we laid geogrids (high strength plastic net) on the subgrade centered on the border vicinity of the faulting of the cut-cmbankmcnt soil and the embankment surface as a countermeasure for this pavement section. This construction method has the effect restraining it to a (tild settlement by relieving the differential settlement of the cut embankment border, preventing faulting and increasing the curvature at the time of settlement (refer to Photograph-3). Furthermore, this geogrids also provides a ground reinforcement effect that supports loads due to its tensile strength and prevents the penetration of poor subgrade soil into the base layer.



Photograph-3 Laying of the geogrids

2) Pavement structure

The said soil is clay matter with a high water content and has been determined to be be a soft subgrade with a design CBR - 2? as the result of laboratory CBR tests. As a consequence, in embankment points with low CBR values the aforementioned geogrids is laid as a countermeasure for soft subgrades. Moreover, since Sky Road is a main street sidewalk, when we considered the required strength of the pavement structure we assumed it would be used by administrative type vehicles with a maximum loading of 4 tons in addition to pedestrians and bicycles and thus decided on a roadbed of 30 cm composed of graded crushed stone and a crusher run as shown in Figure-3.

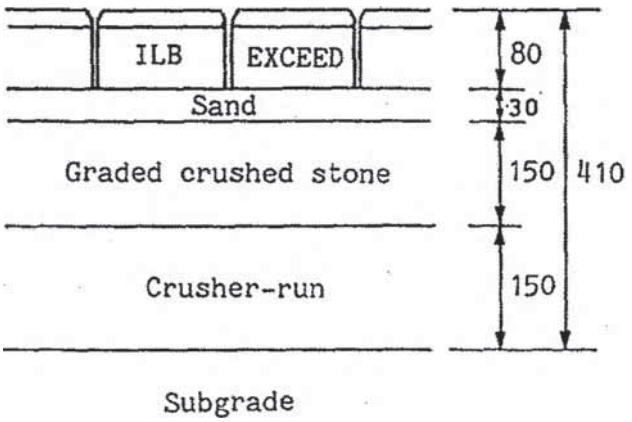


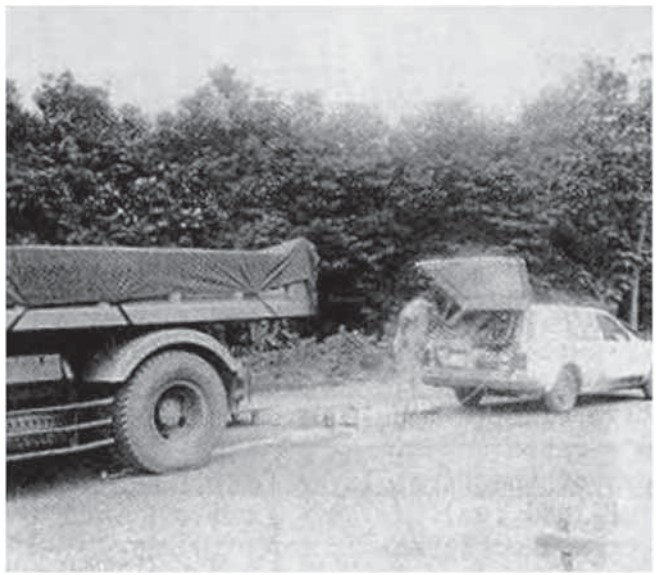
Figure-3 Pavement structure

3-4 Structural evaluation of the road floor and road bed

1) Measurement using a DC meter

When ILB EXCEED is applied, there is concern over a lack of bearing strength and for the subgrade and roadbed due to the relative softness of the subgrade soil and the rapid execution of the embankment work. Consequently, we performed structural evaluation tests using the non-destructive method on the base course. We used the DC (deflection and curvature) meter shown in Photograph-4 for the tests. This DC meter is equipped with a curvature meter at the tip of the arm of the Benkelman beam tester which was used to estimate the bearing strength of the asphalt pavement surface and the roadbed surface.

The method of measurement uses a wheel load adjusted to 5 tons and simultaneously measures the deflection amount and the deviation deflection at the fulcrum center point of the curvature meter directly under the wheel load by establishing the beam tip of the DC meter 30-40 cm frontwards, from directly under the following wheel load and causing it to travel at a speed of 2-3 km/hr. From the measured amount of deflection and the deviation deflection it is possible to estimate the radius of curvature (Figure-4) that exhibits the shape of the deflection curve produced at the time the wheel load is imposed on the pavement, thus permitting an evaluation of the nature of the pavement structure.



Photograph-4 Measurement using a DC meter

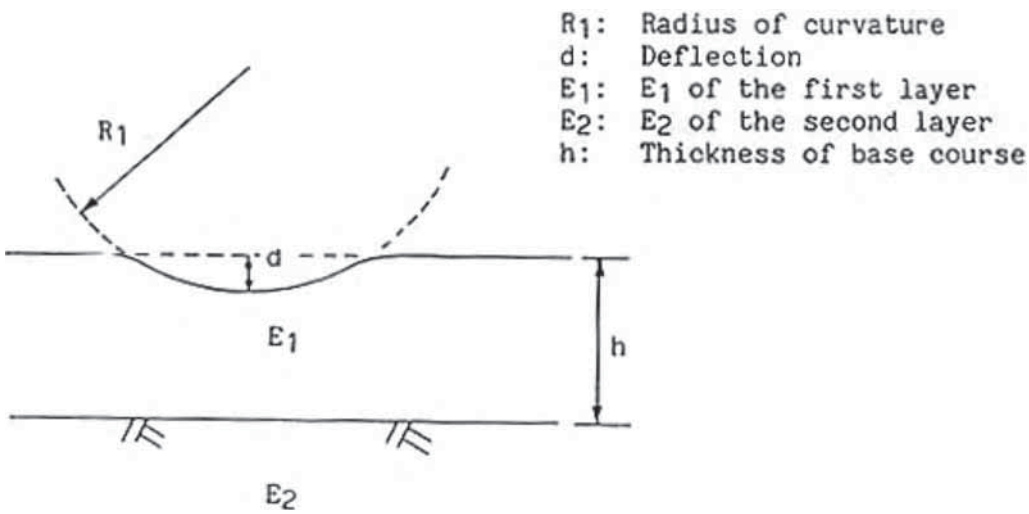


Figure-4 Shape of the deflection curve

2) Method of evaluation

We will evaluate its bearing strength by estimating the elastic modulus (E_1, E_2) of the subgrade and roadbed from the following formula by making the pavement structure into a double structure as shown in Figure-5, using the radius of curvature estimated from the measured values for the amount of deflection and deviation deflection.

$$Wo = \frac{2(1-u_2^2)pa}{E2} \bullet Fwo \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (1)$$

$$Ro = \frac{a \bullet E2}{(1-u_2^2)P} \bullet FRo \quad \cdots\cdots\cdots\cdots\cdots\cdots \quad (2)$$

Where,

FWo, FRo: $f(E_1/E_2, h/a, u_1, u_2)$
Respective coefficient of settlement and coefficient of curvature

E_1, E_2: Respective elastic moduli of the first layer and second layer

u_1, u_2: Poisson's ratio

h: Thickness of the first layer (cm)

a: Radius of load (cm)

p: Ground pressure (Kgf/cm^2)

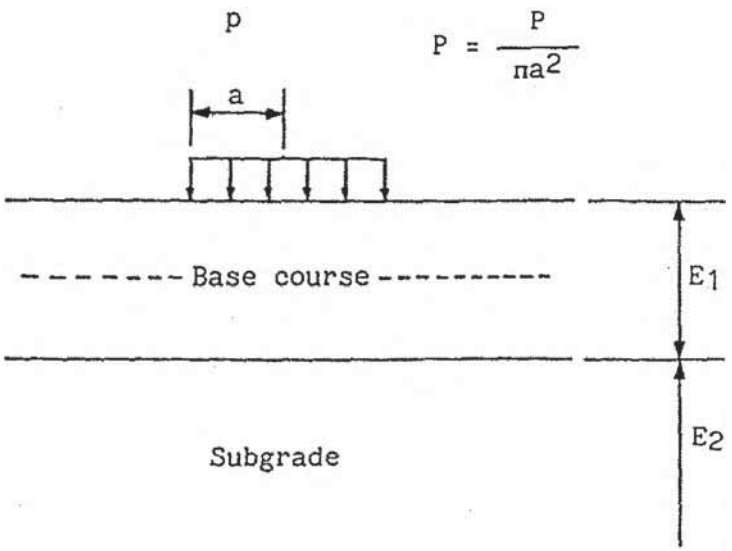


Figure-5 Double structure

3) Results of evaluation

Table-1 shows the measured results using the DC meter and the estimated elastic modulus of the subgrade and roadbed.

From this the following results were obtained.

(1) The elastic modulus of the subgrade soil exhibits a scattering in the range of 90-506 kgf/cm^2 and it may be considered that in the cut soil section and the embankment section there is a considerable disparity in bearing strength.

Table-1 Amount of deflection, diameter of curvature and elastic modulus of each Layer

No	Wr (mm)	σ (mm)	Wo (mm)	R (m)	E_1/E_2	E_1 (kgf/cm^2)	E_2 (kgf/cm^2)
1	1.925	0.974	2.900	14	3.8	980	258
2	1.524	1.320	2.844	8	1.4	644	460
3	1.122	0.725	1.847	17	2.5	1,266	506
4	1.416	1.069	2.485	11	1.9	829	436
5	2.400	0.960	3.360	15	5.6	1,044	186
6	4.140	1.040	5.180	15	11.0	993	90
7	1.296	0.659	1.955	20	3.6	1,412	392
8	2.700	0.706	3.406	22	10.0	1,455	145
S	4.770	1.898	6.668	7	5.0	491	98
10	3.006	1.034	4.040	14	7.0	972	139
11	2.268	0.827	3.095	18	6.6	1,236	187
12	1.161	0.648	1.809	20	3.2	1,439	450
13	3.600	1.866	5.466	7	3.4	494	145
X	2.410	1.056	3.466	14.5	5.0	1,020	269
s	1.187	0.414	1.499	5.02	2.9	337	156

(2) Since in the CBR and the elastic modulus (E) of the subgrade there is the relationship E = 1OO*CBR, the CBR of the subgrade may be inferred to be 0.9-5.1% and agrees with the results of the laboratory CBR tests (CBR = 1.5~5.0).

(3) Shell Oil has set the following relationship formula for the elastic modulus of the subgrade (Es) and roadbed (Ebs) in the double structure.

$$Eba - K \bullet Es \quad K=0.206 \times h_2^{0.45} \quad 2<K<4 \quad .... \quad (3)$$

Consequently, when the average elastic modulus (Es = 269 kg/cm2) for the subgrade soil estimated using the DC meter, the theoretical elastic modulus of the road bed layer is 720 kgf/cm^2.

In contrast to this, the elastic modulus estimated using the DC meter largely exceeds this theoretical value and exhibits 1,020 kgf/cm2 on average. Furthermore, since the smaller the elastic modulus of subgrade the higher the elastic modulus of the roadbed layers, the rolling effect of the roadbed layer increased due to the geogrid laid out in the subgrade soil and thus contributes to increasing the bearing strength.

From the above measured result, we confirmed that the bearing strength of the subgrade and the roadbed fully met the design values.

3-5 Erection work for ILB EXCEED

Since in Sky Road there are curved sections in 10 points to match the size, in case of a design where the pavement surface of an overall length of about 4 kilometers is developed along one theme, it has become an important point to execute the work such that the design characteristics will not be lost in this curved section.

Thereupon, we subdivided these curved sections into 2~4 etc. according to the design characteristics and configuration (diameter, angle, length)

and established the construction joints in the cross direction to the boundaries of the divisions. On the spans surrounded by these construction joints we provided a fixed angle calculated in advance form the configuration of the curved section, then executed the work after reorienting the block into a straight line. Using this method, we were able to hold the gap between the design drawing and the actual location to the smallest possible and were thus able to provide it without losing the design characteristics.

4, Postscript

1) The 44,000 m2 project of the pavement for Sky Road, representing the first period, was completed in October 1989. When a part of the Chichibu Park is opened in 1992, it is projected that the extensive road sketch, that have been given the "theme of the creation of the universe," will extend about 70,000 m^2.



Photograph-5 The completed Sky Road

2) For the creation of a "road" befitting the city scene of recent years, what is called for is not simply the mundane function of pedestrian and vehicle traffic, but rather the diverse functions of a place abounding in intimacy and charm, offering an interchange among people and nature. To achieve this, an effect evoking visual pleasure and providing identity and beauty is required in the road surface and thus the pavement materials used must offer such features as pavement patterns, design, coloring and texture.
   As such, the road pavement is positioned as an important element in the composition of the city scene. The ILB EXCEED introduced here is a composite material providing the combined functions of tiles and concrete block for pavement and we are convinced that it is a product that will adequately meet such needs as these. To meet demands such as diversifying pavement needs, the call for more functions and higher performance and higher added valued, we feel that development and research related to such new materials and new technology will in the future prove more indispensable than ever.
   Extensive road surface sketch using the tile composite concrete block (ILB EXCEED) pavement laid in resort areas.