THE CONSTRUCTION OF NEW TYPE SAND TRACK ON THE BASIS OF SOIL ENGINEERING

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INTRODUCTION

The nationalized racing of Japan takes place in nine race tracks at present. Those race-tracks except Chukyo Race Track have turf courses or the surface covered with lawn.

However, in large tracks, the number of races recently increased up to 40 days a year, and tracks are also used in winter. Then the lawn is damaged seriously, and there is not enough time to repair it. Even if it is repaired only by patching of depressions, the homogeneity of track surface can not be secured.

The race-track of sand course which are widely used in the United States and some other countries are considered to be studied in order to realize a race track of the international standard and to utilize mechanical powers for the maintenance of race-tracks. Prior to the construction of a new type race track by the Japan Racing Association, mechanical properties of the soil were investigated.

The new track is located inside of Tokyo Race Track where Japan Derby Stakes are held. An oval course having the width of 25 m. and the total length of 1,900 m. is to be completed by the end of this year (see Fig. 1).

Fig. 1. General Plan of the Tokyo Race Track

The process of exploration was, at first, to study existing race tracks in textures and mechanical characteristics of subgrade soils, and to conduct a series of laboratory experiments with a model of sand course that was designed in place of existing turf

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course, then to study some selected test sections of sand track which were actually built according to the results of laboratory experiments. The results of the study for the test sections was to be finally reviewed in contrast with the results of studies or riding conditions.

THE STRUCTURE OF FORMER TRACKS AND THE CONCEPTION OF NEW SAND TRACKS

The structure of race tracks is composed of a surface course of lawn or loose sand or a cushion to absorb shock of horse steps and, below the surface course, a well compacted base course. The subgrade below the base course has a character to maintain the resilience of a racetrack, though untreated natural ground has been used as conventional subgrade.

A main fault experienced in former race tracks is that they are not protected from rainfall. Since former track is nothing but a lightly graded surface of a base course of poor drainage, surface water is not well drained and softens the surface into mud (see Fig. 2).

Fig. 2. Puddled Race Tracks After Rainfall (Niigata Race Track)
Left: Turf Course
Right: Sand Course

A method to avoid that fault is, as used in tracks of stadiums which are required to be finished in a flat level, to design the structure of track so as to drain water readily in vertical direction through its base course into subgrade. In other words, base course well compacted and also good for drainage has to be provided. The author recommended an "en tout cas" base course for this purpose.

The new conception of a sand track in comparison with a former turf track is shown in Table 1.

Table 1. The Comparison of New and Old Race Track

Course	Old Track	New Sand Track
cushion course	lawn	loose deposit of sand
base course	compacted clay	compacted pervious soil
sub-base course	compacted natural deposits	resilient and pervious course grained soil
subgrade	natural deposits	compacted natural deposits

SOIL EXPLORATION

The exploration on the properties of soil of race tracks was conducted to obtain quantitative results on the cushion action of surface course, and also on the bearing capacity and permeability of base course.

It was a difficult problem to obtain a quantitative value indicating the cushion action of surface course. At first, a plate bearing test similar to the field CBR test (see Fig. 3) and dynamic bearing test, recording vertical displacement of plate due to dynamic loading, were performed. But, afterwards, it was intended to devise a measur-

Fig. 3. Static Bearing Test with a Circular Plunger of 5 cm in Diameter

Fig. 4. Laboratory Experiment as to Model Sections with a Dynamic Reaction Apparatus

Fig. 5. Measurement of Dynamic Reaction

ing apparatus of dynamic reaction and to measure the actual dynamic resistance of ground (Fig. 4). The apparatus consists of a circular plate of 13 cm. in diameter (the average diameter of a horse's foot print) and a drop hammer guided with a stem. The dynamic resistance when the hammer drops onto the ground was obtained from the strain indicated by a strain-gage installed on the stem. The strain was automatically recorded by an oscillograph as shown in Fig. 5. One of the recorded data is shown in Fig. 6. It was the reason why this kind of apparatus was used for the compara-

Fig. 6. Example of Records of Dynamic Reaction Measurement

Fig. 7. In Situ Permeability Test

tive study of cushion course that the dynamic resistance for stepping of a horse was considered to be the most direct factor to compare the cushion action. However, the weight of a horse exceeds 300 kg., whereas the weight of the drop hammer is about 20 kg. Many other problems like this have to be considered when the test results are applied for practical cases.

In order to measure the permeability, a bottomless drum-can was placed on the ground as shown in Fig. 7, and water was filled in it. The permeability was obtained from the rate of fall of water head. In the case of laboratory study, water was poured onto the surface of a model section which was built in the can, and it percolated through the model section and flew out of bottom. The permeability of the materials in the can was measured by both constant head method and variable head method.

In order to measure simply the bearing capacity of a base course or other courses, the dynamic penetration test in which the number of blows per a certain definite length of penetration of a cone penetrometer having the diameter of 3 cm. and the point angle

Fig. 8. Dynamic Penetrometer

Fig. 9. Riding Conditions vs. Static Penetration Values

of 60 degrees driven with a constant energy (weight of hammer of 5 kg., and drop height of 50 cm.) was carried out. The Swedish sounding method was also used at first, but no good result was obtained for the soil layers liable to variation from place to place.

The measurement of soil properties, such as density, water content, and grading of materials, was performed with the test methods as mentioned in this article.

THE RESULTS OF EXPLORATION

The race tracks used at present are tracks of turf course as mentioned previously, but all of them have sand tracks for practice inside of turf track for race. The exploration was carried out for those sand tracks in addition to the existing turf tracks.

The various amount of resistance for static penetration under different weather conditions are shown in Fig. 9. The water content of the soil of race tracks is taken

Fig. 10. Model Sections

in abscissa. It is interesting that the water content does not contradict the conventional expression of track conditions as “heavy” or “good”. It is also supposed that turf tracks show relatively stable resistance against a wide variation of water content.

As the next step of exploration, five model sections as shown in Fig. 10 were selected in reference to the sections of actual tracks. Those model sections were built in drum-cans with the same materials as prototype. The testing on dynamic resistance, permeability and bearing capacity of model sections was carried out. It was concluded from the testing that en tout cas base course was practically valuable because of good drainage characteristics, and that the structure to give the resilience to subgrade was worthy of study.

It was confirmed at first from the testing that the measuring apparatus of dynamic resistance would be valuable for the comparative study on the cushion action of surface courses.

The grading of surface course materials differs with race tracks. In the United States, as shown by the name of “dirt course”, a slight amount of organic compound is mixed to give some tenderness to surface course.

A few examples of actual grading are shown in Fig. 11. The grading curves of

Fig. 11. Grading Curves of Sand Course Materials

course and fine sand used for the test course which is mentioned in the foregoing article are also plotted in it.

CONSTRUCTION OF TEST TRACKS

After summarizing the results of exploration as mentioned in the previous sections, the construction of test tracks was started. Three test tracks, each 80 m. wide and 50 m. long, were laid in Equestrian Park, Setagaya, Tokyo (see Fig. 12 a). Not only the study of soil properties but the comparison of riding condition was also carried out.

The sections used for test tracks are as shown in Fig. 12 b. The A-course in

which en tout cas base course of 5 cm. in depth is used is sub-divided into three, each constructed with different combinations of materials. Sand mixed with saw dust, specific gravity being made greater with absorbed creosote oil, is used for the B-course

Fig. 12. Tes Courses Constructed in the Equestrian Park

in order to introduce resilience. The C-course has special structure modified from that of some race tracks in Puerto Rico, a country of excessive rainfall. No soil compound is used for it and very high permeability of base course is desired.

For each course, measurement of cushion action of surface course and base course with an apparatus of dynamic reaction, measurement of permeability of base course by means of an in-situ permeability testing device, and penetration test with a dynamic penetrometer were successively carried out.

In order to come closer to the properties of these test courses, a new training sand track of Tokyo Race Track which has almost similar section to the aforesaid tracks and a turf track and a sand track of the Tokyo Race Track were in the same way explored. The results of them were finally reviewed and compared.

The results of measurement of dynamic reaction of base course and surface course are shown in Fig. 13 and 14. In these figures the relationship between dynamic reaction and drop height of a 50 kg. hammer is illustrated. As to the dynamic reaction of base course, the sand track of Tokyo Race Track has a remarkably large reaction, and the B-course containing saw dust shows the minimum reaction as expected because of its resilient properties. The dynamic reaction of the other tracks lies between these extremes, and there is no large difference between them.

Dynamic reaction measured on the top of surface course consisting of a 6 to 7 cm. thick sand layer placed on base course is shown in Fig. 14. The reaction in this case seems to be mostly due to the hardness of base course and also to the properties of surface course materials (grading, water content, etc.), as well as the thickness of

Fig. 13. Comparison of Dynamic Reaction of Base Courses

Fig. 14. Comparison of Dynamic Reaction of Surface Courses

Fig. 15. Comparison of Dynamic Reaction for Different Thickness and Grading of Surface Course Material

surface course. These relations are well indicated in Fig.15.

In this figure, variation in dynamic resistance for a definite amount of driving energy (20 kg. $\times$ 20 cm.) with varied thickness of surface course is plotted for two kinds of base courses; hard one is the sand track of Tokyo Race Track, and soft one the model section No. 1 (see Fig. 10). It is obvious that the reaction of surface course is seriously affected by that of base course when the thickness of surface course is too small. It is also noted that the reaction is greater for coarser grading of materials. The effect of water content is not so direct as grading. It may be generally said that the material having smaller static bearing capacity shows smaller dynamic resistance.

Fig. 16. Results of Permeability Test

The results of permeability tests for each kind of courses are shown in Fig. 16. The permeability of base course, which is made much of for design and construction

of the test courses, is shown by one order greater or 10^{-3} cm/sec as compared with that of base course for conventional structures.

The values of dynamic resistance in penetration test have shown a considerable deviation from place to place, but the approximate value is 30 times per 10 cm. for the turf courses, 10 times per 10 cm. for the new training sand track, 40 to 100 times per 10 cm. for the existing sand tracks, and 30 times per 10 cm. for the en tout cas base course. The value for the new sand track is small as it has not yet been opened for use, but it will possibly become as hard as the base course of the existing sand tracks after used for a long period.

THE SUMMARY OF EXPLORATION AND THE DESIGN OF NEW RACE TRACKS

From the results of exploration as discussed in the previous sections, many instructive conclusions have been derived.

The base course of compacted diluvial sand as the former sand track of Tokyo Race Track gradually increases in hardness. Therefore, in order to keep its initial hardness, it is necessary to repeat maintenance daily so as to loosen the uppermost crust of base course.

Little perviousness can be expected from the above base courses, whereas slight vertical drainage through en tout cas base course may be anticipated. Consequently, en tout cas base course seems to be a preferable structure in such a rainy country as Japan. However, en tout cas base courses have to be much strengthened, since the

Fig. 17. Section of the New Sand Track

load applied on race track is quite larger than that on tracks of athletic stadia. Furthermore, drainage capacity of en tout cas base course should not be deteriorated by placing surface course materials on it. For the structure, such as B-course, composed of highly elastic subgrade materials beneath base course, much dynamic reaction of surface course may be effectively absorbed, but there are some problems how to fully compact both base course and subgrade. The durability of this type of structure is also questionable.

For the test track C-course, a new type of race track section, complaints from the results of riding tests are being heard that the course is hard to ride along because of its extremely thick surface layer of coarse sand. Anyway, it will be a problem to be solved in the near future what kind of material is best suited for sandy surface course materials. Organic additives to soften surface course may result in filling voids of a base course and making it impervious. So this problem seems to be difficult to solve so far as the drainage of base course is taken into consideration. In accordance with the results of soil exploration and also the comparative study of riding conditions, the structural section as shown in Fig. 17 was selected for the new race track.

This section is something like a combination of present sand tracks and model section A. The designed section may be too common place for the results of the ambitious comparative study of riding conditions. The reason why this was selected are as follows: en tout cas as used in the thickness of 5 cm. is unreliable as to bearing capacity, although it is most suitable from the view point of drainage; it was inferred that the en tout cas base courses thicker than 5 cm. would be economically impracticable; even if the perfect drainage of surface courses is impracticable, in order to insure better drainage, gravel subgrade is required beneath the surface course; in this case, the material mixed with volcanic pebbles and cinder should be inserted between base course and subgrade in order to maintain the resilience of race track.

The transverse slope of 1/50 was given to the surface of base course in order to facilitate surface drainage, though vertical drainage through base course was given up.

The construction of this new track is now in progress, and it is controlled on the bases of soil engineering. The base course of en tout cas is expected to be used for small scale riding grounds or polo fields, though it is not applicable to large scale race tracks.

The measuring apparatus of dynamic reaction devised for this exploration is considered to present a new method to evaluate in situ the mechanical properties of surface courses, and also contribute to the future development of other fields of soil engineering.

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