Bearing capacity evaluation of asphalt pavement based on dynamic deflection equivalent

Qian Fan 1,2, *, Shanqiang Li 1,2, Xinquan Xu 1,2
1 Guangdong Transportation Technology Testing Co., Ltd., Guangzhou, Guangdong 510550, China.
2 Guangdong Hualu Transportation Technology Co., Ltd., Guangzhou, Guangdong 510420, China

* Corresponding author email: cumtfanqian@163.com

Abstract. In order to accurately evaluate the bearing capacity of asphalt pavement structure, the research group, on the basis of real-time temperature data of five kinds of asphalt pavement structure in Daxin experimental road, obtain the dynamic modulus main curves of various types of pavement materials and FWD dynamic modulus of the load acting frequency through dynamic modulus research in laboratory, and determine the dynamic modulus of the pavement structure material true value. According to the principle of dynamic deflection equivalent, this paper puts forward the evaluation method of predicting the bearing capacity of asphalt pavement based on composite modulus determination, pavement structure inverse calculation and bending stiffness modulus attenuation threshold. The evaluation results of five kinds of asphalt pavement structure bearing capacity of experimental road are consistent with the actual performance, which shows that the evaluation method of bearing capacity of asphalt pavement structure based on dynamic deflection equivalent is reasonable and effective.

Keywords: Road Engineering; Evaluation of bearing capacity; Dynamic deflection equivalent; Composite dynamic modulus; Dynamic modulus threshold.

1. Introduction
Accurate and effective grasping the bearing capacity of asphalt pavement structure and predicting its changing law is of great significance to pavement design, construction and maintenance. However, Highway Performance Assessment Standards (JTG H20-2007) [1] is to evaluate the bearing capacity of the asphalt pavement according to the comprehensive index of the pavement structural strength index, and it is impossible to coordinate the relationship between the structural layer and the bearing capacity, so the bearing capacity of the asphalt pavement cannot be accurately evaluated; After the birth of the Falling Weight Deflectometer (FWD), the modulus of each structural layer is related to its bearing capacity, which opens up a path for the evaluation of the bearing capacity of asphalt pavement.

FH Scrivner (1968) compiled a nomogram of the dynamic modulus inverse calculation of pavement structure, and proposed the FWD deflection basin inverse calculation modulus model for the first time [2]; Subsequently developed MODCOMP (Irwin, 1983), WESDEF (1989).), MODULUS (Uzah, 1988)
[3-4], SIDMOD (Wang Fuming, 1996) [5] and other inverse calculation procedures. In 2005, by comparing the initial value sensitivity, user sensitivity, fitting error, inverse calculation accuracy and practicability of SIDMOD and MODULUS, MODCOMP and WESDEF software, it shows that SIDMOD has the highest inverse calculation accuracy in the “surface + base + subgrade” 3-layer pavement structure [6]. On this basis, Tang Boming (1989) established the relationship between pavement surface deflection and performance, and proposed the subgrade, base and surface elastic modulus estimation formulas [7]; Huang Wei (1998) established the correlation between pavement surface deflection and compressive strain on the top subgrade [8]; Hee Mun Park (2001) established the correlation between road surface deflection index and pavement structure performance based on the inverse calculation modulus of asphalt pavement structure layer [9]. Subsequently, a comparative study on the inverse calculation modulus and the indoor dynamic modulus is also emerging. AASHTO (1993) [10] and FHWA (1994) [11] respectively considered that the inversion calculation modulus is more than twice the static modulus. Zeng Sheng (2003) has obtained a well correlation between dynamic modulus and static modulus, and changes with the depth of the rigid layer, tending to be stable within a certain depth [12]. Zhi Fengyu (2005) believes that the inverse modulus of asphalt surface and base is basically within the range of indoor dynamic modulus, while the soil-matrix inverse calculation modulus is small and the variability is the smallest, the surface modulus variability is higher, and the base modulus is the most variability [13].

In summary, based on the inverse calculation modulus using the deflection basin, the existing research can be roughly divided into three categories: (1) Obtain the modulus of each structural layer according to the inverse calculation program, and then calculate the stress and strain of the pavement structure by using the elastic layer theory, and then analyze the remaining life of the pavement by the fatigue equation; (2) Using regression analysis and other means to establish the relationship between the pavement deflection basin index and the pavement structure performance to evaluate the pavement structure bearing capacity; (3) Establish the relationship between the inverse calculation modulus and the material modulus to evaluate the bearing capacity of the pavement structure.

However, the error accumulation in the two stages of inverse calculation modulus and fatigue life estimation in the first type of study will result in lower precision; The estimation formula in the second type of study only reflects the performance of the single aspect of the surface, and the applicability is not high; The third type of research is closely related to the relationship between the inverse modulus and the material modulus, but ignores the influence of temperature on the asphalt material, resulting in greater variability and poor feasibility.

Therefore, this paper relies on the real-time temperature monitoring data of five pavement structures in the test pavement of Daxin Expressway. According to the principle of "dynamic deflection and equivalent", an evaluation method for the bearing capacity of asphalt pavement based on composite modulus determination, inverse analysis of pavement structure and bending stiffness modulus attenuation threshold is proposed. Due to the consistency of the inverse calculation composite modulus and the inverse calculation pavement material modulus, the systematic error in the inverse calculation process is eliminated. It overcomes the problem of poor accuracy of the existing structural layer modulus inverse calculation and poor feasibility of the asphalt pavement structure bearing capacity evaluation system.

2. Overview of test pavement
The five types of pavement structure in the Daxin Expressway test pavement are shown in Table 1. The upper layer adopts 4% SBS+4% UII composite modified asphalt; The middle layer adopts 3.5% SBS modified asphalt; The lower layer and the flexible base are all adopt 70# matrix asphalt.
Table 1. Structure of Daxin Expressway Research and Test Road

| structure | Asphalt pavement structure type                          |
|-----------|----------------------------------------------------------|
| 1         | 4cmAC-16+6cmAC-20+8cmAC-25+15cmAC-30+35cm graded crushed stone |
| 2         | 4cmAC-16+6cmAC-20+8cmAC-25+15cmAM-30+35cm graded crushed stone |
| 3         | 4cmAC-16+6cmAC-20+8cmAC-25+15cmATB-30+35cm graded crushed stone |
| 4         | 4cmAC-16+6cmAC-20+8cmAC-25+36cm cement stabilized macadam  |
| 5         | 4cmSP-12.5+6cmAC-20+8cmAC-25+36cm cement stabilized macadam |

3. Principle of dynamic deflection equivalence
The dynamic deflection equivalent principle is used to convert the indoor dynamic modulus true value into the composite modulus or standard dynamic modulus of each structural layer. The specific application methods are as follows: The temperature sensor is embedded in the five structures to obtain the real-time temperature of each structural layer, combined with the main curve and the shift factor obtained by the dynamic modulus test of the asphalt mixture, the true modulus of the dynamic modulus of each structural layer at the corresponding temperature can be obtained. The dynamic modulus true value is input into the Bisar 3.0 calculation software, and the interlayer contact conditions are set to be completely continuous to obtain the deflection basin corresponding to each structure; According to the deflection basin, the inverse calculation program is applied to obtain the composite modulus of each structural layer. In the inverse calculation process, the interlayer contact condition is assumed to be completely continuous, and the composite modulus is called the standard dynamic modulus.

4. Dynamic modulus true value
4.1. Asphalt mixture dynamic modulus true value
The literature [14] shows that the structural resistance of asphalt mixture and the performance of binder have a significant influence on the dynamic modulus. According to this, the asphalt mixture can be classified to study its dynamic modulus. The dynamic modulus master curves of the same kind of mixture can mutually reference. According to the type of asphalt mixture of the test pavement, when the binder is the same, AC-13 and Superpave 12.5, AC-25 and AC-30, AM30 and ATB30 are classified into one category.

After classification, the dynamic modulus test of seven kinds of mixture was carried out in the room. The test temperature was -10 °C, 5 °C, 20 °C, 35 °C, 50 °C, load frequency 0.5 Hz, 1 Hz, 2 Hz, 5 Hz, 10 Hz, 20Hz, 25Hz. The test results are shown in Table 2.

According to the temperature sensor embedded in each structural layer, the real-time temperature of each structural layer was measured, and the dynamic modulus main curve model established in Table 2 was used to obtain the true value of the dynamic modulus of each asphalt layer, as shown in Table 3.
Table 2. Master curve model of 20 °C reference temperature

| AC-13  | $\lg(|E^*|) = 2.3251 + \frac{1.204728}{1 + e^{-0.15765 + 1.68074 \lg t}}$ |
|--------|-------------------------------------------------------------------------------------------------|
| AC-16  | $\lg(|E^*|) = 2.3399 + \frac{1.194304}{1 + e^{-0.19819 + 1.53588 \lg t}}$ |
| SMA-13 | $\lg(|E^*|) = 2.59455 + \frac{0.922778}{1 + e^{-0.14985 + 1.79636 \lg t}}$ |
| AC-20  | $\lg(|E^*|) = 2.5129 + \frac{1.037643}{1 + e^{-0.405311 + 1.42292 \lg t}}$ |
| AC-20  | $\lg(|E^*|) = 1.6428 + \frac{1.907734}{1 + e^{-0.23399 + 1.07112 \lg t}}$ |
| AC-25  | $\lg(|E^*|) = 1.83545 + \frac{1.711808}{1 + e^{-0.28619 + 1.36773 \lg t}}$ |
| ATB-30 | $\lg(|E^*|) = -0.03394 + \frac{3.578888}{1 + e^{-3.51671 + 0.78461 \lg t}}$ |

Remarks: $|E^*|$—Asphalt Mixture Dynamic Modulus (KSI); tr—Loading time (s) at reference temperature.

Table 3. The true modulus of the asphalt layer of Daxin Scientific Research Road

| structure | Upper layer | Middle layer | Lower layer | Flexible base |
|-----------|-------------|--------------|-------------|---------------|
|           | temperature /℃ | Modulus / MPa | temperature /℃ | Modulus / MPa | temperature /℃ | Modulus / MPa | temperature /℃ | Modulus / MPa |
| E         | 16.2        | 20047        | 14.4        | 19101         | 10.2        | 20461         | 6.7          | 23904         |
| F         | 22.4        | 18720        | 16.5        | 18451         | 11.9        | 20016         | 7.5          | 23893         |
| G         | 19.9        | 19286        | 16.4        | 18482         | 12.0        | 19988         | 7.8          | 23888         |
| N         | 23.5        | 19536        | 18.6        | 17757         | 12.8        | 19765         | -            | -             |
| O         | 24.2        | 18418        | 18.8        | 17689         | 12.7        | 19793         | -            | -             |

4.2. Base material dynamic modulus true value
The synthetic grade of the cement stabilized macadam base layer of the test pavement are shown in Table 4; the ratio of the cement-lime-flyash stabilized macadam is cement: lime: flyash: macadam = 2:5:13:80, of which 1-3cm gravel : 0.5-1cm gravel: aggregate chips = 30:25:45; test using 42.5 P•O cement. After the test piece is molded, it is cured for 28 days under the standard curing conditions of the laboratory (20°C ± 2°C, relative humidity≥95%), and then sealed and stored at room temperature for 180 days before the test. The dynamic modulus test was carried out using the side method using MTS, and the test control target strain was 30 to 40 microstrain. The dynamic modulus of the inorganic binder stabilized macadam material was measured by using 7 loading frequencies of 35, 30, 20, 10, 5, 1, 0.5 Hz; Since the cement stabilized macadam is not a temperature sensitive material, the test temperature is a constant temperature of 20 ºC. The test results are shown in Table 5.

The FWD load action time is about 0.28 s, and the converted load frequency obtained is about 35 Hz. Therefore, the true modulus of the obtained cement stabilized macadam is 1435.4 KSI=9818 MPa, and the true modulus of the cement-lime-flyash stabilized macadam is 274 KSI=1874 MPa.
Table 4. Cement Stabilized Mixture Design Gradation

| Sieve Aggregate | Through sieve (square hole sieve, mm) percentage (%) |
|-----------------|-----------------------------------------------|
| 31.5            | 26.5                                          |
| 20-30mm         | 89.9                                          |
| 10-20mm         | 100                                           |
| 5-10mm          | 100                                           |
| 0-5mm           | 100                                           |
| Synthetic grading | 98.9                                           |

| Through sieve (square hole sieve, mm) percentage (%) |
|-----------------------------------------------------|
| 26.5                                                |
| 20.3                                               |
| 19.5                                               |
| 9.5                                                |
| 4.75                                               |
| 2.36                                               |
| 0.6                                                |
| 0.075                                              |

| 26.5                                                  |
| 20.3                                                 |
| 19.5                                                 |
| 9.5                                                  |
| 4.75                                                 |
| 2.36                                                 |
| 0.6                                                  |
| 0.075                                                |

| 20.3                                                  |
| 19.5                                                 |
| 9.5                                                  |
| 4.75                                                 |
| 2.36                                                 |
| 0.6                                                  |
| 0.075                                                |

| 19.5                                                  |
| 9.5                                                  |
| 4.75                                                 |
| 2.36                                                 |
| 0.6                                                  |
| 0.075                                                |

| 9.5                                                   |
| 4.75                                                 |
| 2.36                                                 |
| 0.6                                                  |
| 0.075                                                |

| 4.75                                                  |
| 2.36                                                 |
| 0.6                                                  |
| 0.075                                                |

| 2.36                                                  |
| 0.6                                                  |
| 0.075                                                |

| 0.6                                                  |
| 0.075                                                |

| 0.075                                                |

Table 5. Dynamic stability test results of cement stabilized macadam

| test results | Dynamic modulus (KSI) at different frequencies |
|--------------|-----------------------------------------------|
| 0.5 Hz       | 1 Hz  | 5 Hz  | 10 Hz | 20 Hz | 30 Hz | 35 Hz |
| cement stabilized macadam | 1037.2 | 1084.6 | 1136.7 | 1164.3 | 1219.3 | 1316.9 | 1435.4 |
| cement-lime-flyash stabilized macadam | 196.6 | 217.7 | 222.7 | 221.1 | 231.3 | 257.1 | 274.0 |

4.3. Substrate material and soil matrix modulus true value

Due to the weak cohesion of the cement stabilized gravel soil and the pellet material, the test piece is difficult to form, and it is difficult to obtain the dynamic modulus value by the test method of the laboratory. The author used the FWD test to calculate the dynamic elastic modulus of cement stabilized gravel, pellet material and soil foundation during the construction period of Daxin test pavement. The true value of the dynamic modulus was determined on the basis of ensuring the subbase compactness of the test section ≥97%, the soil base compaction degree ≥96% and the strength was reasonable, as shown in Table 6.

Table 6. Substrate material and soil matrix modulus true value

| material type                  | Inversion calculating dynamic rebound modulus (MPa) | Dynamic modulus true value (MPa) |
|-------------------------------|-----------------------------------------------------|---------------------------------|
| graded crushed stone          | 500~800                                             | 500                             |
| cement stabilized sand gravel | 700~900                                             | 700                             |
| Soil base                     | 150~180                                             | 150                             |

5. Dynamic modulus attenuation threshold

In order to study the dynamic modulus attenuation threshold, this paper carries out the relationship between the dynamic compression modulus and the bending modulus of asphalt mixture and cement stabilized macadam material under the same temperature (20 °C), the same frequency (10Hz) and different stress ratios.

The test results are shown in Table 7, Under different stress ratios, the dynamic modulus and bending modulus ratio of AC-20 are basically equal. The dynamic modulus is the same as the bending modulus, which indicates that the bending modulus is consistent with the dynamic modulus. In order to verify this conclusion, on the basis of AC-20, this can also be obtained by changing the asphalt type (4.5% SBS modified asphalt), adding anti-rutting agent (0.4% Lobo), adding fiber (0.35% fiber). In addition, as shown in Table 8, the ratio of cement stabilized macadam at different stress ratios can also be concluded. Therefore, when it is difficult to obtain the dynamic modulus attenuation law, the attenuation law of the bending modulus can be studied indirectly.
### Table 7. Dynamic compression modulus and bending modulus ratio of each asphalt mixture

| Types                      | Stress ratio |
|----------------------------|--------------|
|                            | 0.4          | 0.6          |
| AC-20                      | 3.80         | 3.75         |
| 4.5% SBS modified asphalt AC-20 | 2.15         | 2.05         |
| AC-20+0.4% Lobo            | 1.65         | 1.60         |
| AC-20+0.35% fiber          | 2.75         | 2.70         |

### Table 8. Dynamic compression modulus and bending modulus ratio of cement stabilized macadam

| Types                   | Stress ratio |
|-------------------------|--------------|
|                         | 0.77         | 0.68         | 0.5          |
| cement stabilized macadam | 17.0         | 16.5         | 16.5         |

Obtaining the attenuation law of dynamic modulus in the laboratory, there is no better method at present. However, the four-point bending constant stress fatigue test in the MTS810 test system can obtain the attenuation law of the bending modulus. This provides a shortcut for studying the dynamic modulus attenuation law and the attenuation threshold.

Therefore, this paper carries out the constant stress loading control fatigue test of asphalt mixture and cement stabilized macadam to determine the attenuation threshold of the dynamic modulus of pavement structure material. The stress level of asphalt mixture adopts three levels of 0.4, 0.6, and 0.8 stress ratio. The stress level of cement stabilized macadam adopts seven levels of stress ratios of 0.77, 0.74, 0.71, 0.68, 0.64, 0.60, and 0.50, and the test temperature is 15 °C. At 20 °C, the test frequency is 10 Hz, and the loading waveforms are all sine waves. The dimensions of the test pieces were 40 mm × 40 mm × 200 mm, and the parallel test was 3 times. The modulus at the time of loading 50 times was taken as the initial modulus. The attenuation modulus refers to the bending modulus corresponding to the turning point at which the bending modulus produces an accelerated attenuation. The dynamic modulus of the pavement material reaches the attenuation threshold, which means that the structural layer enters the rapid decay process of the modulus, and the bearing capacity of the pavement structure is about to drop rapidly. The test results are shown in Tables 9 and 10.

### Table 9. Dynamic bending stiffness modulus decay threshold of asphalt mixture trabecular specimens

| Types                      | Stress ratio | 50 times stiffness modulus (MPa) | Attenuation stiffness modulus (MPa) | Fatigue life (times) | Attenuation threshold |
|----------------------------|--------------|---------------------------------|-------------------------------------|----------------------|-----------------------|
| AC-20+0.35% fiber          | 0.8          | 6380.51                         | 3218.93                             | 492                  | 0.5                   |
|                            | 0.6          | 5988.63                         | 4966.74                             | 1276                 | 0.8                   |
|                            | 0.4          | 5595.77                         | 5686.27                             | 4357                 | 1.0                   |
| 4.5% SBS modified asphalt AC-20 | 0.8          | 6540.54                         | 2973.88                             | 989                  | 0.5                   |
|                            | 0.6          | 5145.4                          | 3887.94                             | 2998                 | 0.8                   |
|                            | 0.4          | 4866.71                         | 3869.74                             | 9634                 | 0.8                   |
| AC-20+0.4% Lobo            | 0.8          | 6155.76                         | 2927.86                             | 398                  | 0.5                   |
|                            | 0.6          | 5731.04                         | 3607.32                             | 765                  | 0.6                   |
|                            | 0.4          | 5542.47                         | 4534.83                             | 3103                 | 0.8                   |
| AC-20                      | 0.8          | 6217.22                         | 3423.67                             | 121                  | 0.6                   |
|                            | 0.6          | 5289.84                         | 4397.12                             | 725                  | 0.8                   |
|                            | 0.4          | 5375.78                         | 5671.79                             | 3963                 | 1.1                   |
Table 10. Dynamic bending stiffness modulus decay threshold of cement stabilized macadam trabecular specimens

| Test piece number | Stress ratio | Initial modulus (MPa) | Critical failure modulus (MPa) | Fatigue life (times) | Attenuation threshold |
|-------------------|-------------|-----------------------|-------------------------------|---------------------|----------------------|
| 1                 | 0.80        | 23580                 | 14712                         | 19244               | 0.6                  |
| 2                 | 0.75        | 23107                 | 14244                         | 37391               | 0.6                  |
| 3                 | 0.70        | 26693                 | 19693                         | 191364              | 0.7                  |
| 4                 | 0.65        | 17409                 | 13211                         | 774578              | 0.8                  |
| 5                 | 0.60        | 17941                 | 13330                         | 1327062             | 0.7                  |
| 6                 | 0.55        | 21255                 | 18219                         | 4198407             | 0.9                  |
| 7                 | 0.50        | 21351                 | 18965                         | 4669484             | 0.9                  |

Table 9 and Table 10 show that as the stress ratio increases, the fatigue life of the trabecular specimen decreases continuously, the dynamic bending stiffness modulus decays faster, and the stiffness modulus threshold decreases. It shows that heavy traffic has a significant effect on the reduction of the service life of the pavement structure.

The general vehicle load on the expressway is in the range of 0.5 to 0.6 stress ratio [15]. Therefore, it is advisable to judge the dynamic modulus attenuation of the pavement structure layer according to the traffic volume of the expressway. The traffic composition can be divided into two types, heavy traffic and light traffic, with the 0.6 stress ratio as the limit.

When the 0.6 stress ratio is above (including the 0.6 stress ratio), the dynamic modulus attenuation threshold of the heavy traffic pavement structure asphalt layer is 0.6; When the 0.6 stress ratio is below, the dynamic modulus attenuation threshold of the light traffic pavement structure asphalt layer is 0.7.

Cement stabilized macadam stiffness modulus is more significant, Therefore, the stress ratio is 0.6 or more (including 0.6) and the stress ratio is 0.6 or less., that is, the baseline dynamic modulus attenuation threshold of the light traffic and heavy traffic pavement structure is 0.7. The same dynamic modulus attenuation threshold of 0.7 is also used for the graded gravel subbase and the water stabilized gravel subbase.

The subgrade is the basis of the strength of the entire pavement structure. The attenuation of the subgrade modulus is extremely important for the impact of the pavement structure bearing capacity level. Therefore, the dynamic modulus of the subgrade should not be determined by the attenuation evaluation method, and the dynamic modulus attenuation threshold is determined to be 1.0. The final determined dynamic modulus attenuation threshold of the pavement material is as described in Table 11.

Table 11. Dynamic modulus attenuation threshold of pavement materials

| Types           | Threshold | Asphalt layer | Base | Subgrade |
|-----------------|-----------|---------------|------|----------|
| Heavy traffic   | 0.6       | 0.7           | 0.7  | 1.0      |
| Light traffic   | 0.7       | 0.7           | 1.0  | 1.0      |

6. Evaluation of bearing capacity of asphalt pavement structure

The traffic volume of Daxin test pavement is about 2,500 vehicles/day, the proportion of trucks is low, and there is no overloaded vehicle, which is a light traffic class. In addition, according to the disease statistics over the years, E, F, G flexible basement pavement without rutting and cracking damage; N, O semi-rigid base asphalt pavement test section has the problem of base layer reflection cracking, no rutting damage.

While collecting temperature for the Daxin test pavement, FWD is used to obtain the pavement structure deflection basin, and then the inverse calculation program is applied to obtain the inverse
calculation modulus of each structural layer. The inverse calculation modulus is called the attenuation dynamic modulus.

Document 6 indicates that the SIDMOD back calculation program has the highest accuracy in the “asphalt layer + base + subgrade” 3-layer pavement structure. Therefore, this paper chooses the SIDMOD inverse calculation program to calculate the modulus of the pavement structure layer for the deflection basin obtained by FWD. In addition, according to the traffic volume of Daxin test pavement and the actual road conditions after opening, it is acceptable to assume that the layers are completely continuous in the inverse calculation process.

Thus, a one-to-one mapping relationship between the standard dynamic modulus and the attenuation dynamic modulus at the same temperature is established. According to the relationship between the ratio of the two and the dynamic modulus threshold, the bearing capacity of the asphalt pavement structure is evaluated.

According to the determined true value of the dynamic modulus of each structural layer of the pavement, according to the principle of “dynamic deflection equivalent”, the standard dynamic modulus, the attenuation dynamic modulus and the ratio of the pavement structure layer at the same temperature are obtained, as shown in Table 12.

| Structure | Station | Standard dynamic modulus / MPa | Attenuation dynamic modulus / MPa | Ratio of standard dynamic modulus to attenuated dynamic modulus |
|-----------|---------|-------------------------------|----------------------------------|---------------------------------------------------------------|
|           |         | Surface Base subgrade         | Surface Base subgrade            | Surface Base subgrade                                         |
| E         | 1-1     | 20100 568 142                | 17653 1015 315                   | 0.9 1.8 2.2                                                  |
|           | 1-2     | 20100 568 142                | 15708 1218 345                   | 0.8 2.1 2.4                                                  |
|           | 1-3     | 20100 568 142                | 13987 1397 377                   | 0.7 2.5 2.7                                                  |
| F         | 2-1     | 19849 549 140                | 15248 409 311                    | 0.8 0.7 2.2                                                  |
|           | 2-2     | 19849 549 140                | 14295 442 268                    | 0.7 0.8 1.9                                                  |
|           | 2-3     | 19849 549 140                | 15478 587 286                    | 0.8 1.1 2.0                                                  |
| G         | 3-1     | 20500 552 151                | 10884 894 405                    | 0.5 1.6 2.7                                                  |
|           | 3-2     | 20500 552 151                | 10912 756 390                    | 0.5 1.4 2.6                                                  |
|           | 3-3     | 20500 552 151                | 9986 821 359                     | 0.5 1.5 2.4                                                  |
| N         | 4-1     | 22000 2118 140               | 19987 1534 360                   | 0.9 0.7 2.6                                                  |
|           | 4-2     | 22000 2118 140               | 18316 1430 340                   | 0.8 0.7 2.4                                                  |
|           | 4-3     | 22000 2118 140               | 18657 1219 365                   | 0.8 0.6 2.6                                                  |
| O         | 5-1     | 22000 2068 145               | 19802 1835 307                   | 0.9 0.9 2.1                                                  |
|           | 5-2     | 22000 2068 145               | 17951 1726 310                   | 0.8 0.8 2.1                                                  |
|           | 5-3     | 22000 2068 145               | 16624 1045 257                   | 0.8 0.5 1.8                                                  |

Compared with the dynamic modulus threshold of Table 11, the ratios of the standard dynamic modulus and the attenuation dynamic modulus of the E, F pavement surface, base and the subgrade are greater than the threshold value, and the pavement structure bearing capacity is better. The standard dynamic modulus and attenuation dynamic modulus ratio of the G pavement surface is less than the threshold value, indicating that the asphalt layer has poor bearing capacity. The standard dynamic modulus and attenuation dynamic modulus ratio of the N and O pavement base is less than the threshold value, indicating that the semi-rigid type base has poor bearing capacity.

The evaluation results of the bearing capacity of the five pavement structures are consistent with the overall performance of the pavement performance, indicating that the proposed bearing capacity evaluation method is feasible and accurate.
7. Conclusion
In this paper, the dynamic modulus master curve of various types of pavement materials and the dynamic modulus data of FWD load frequency are obtained through laboratory experiments to determine the true value of the dynamic modulus of pavement structural materials.

According to the principle of dynamic deflection and equivalent, a method for predicting the bearing capacity of asphalt pavement based on composite modulus determination, inverse calculation pavement structure and bending stiffness modulus threshold is proposed. The evaluation process eliminates the systematic error in the back calculation process, thus overcoming the problem of poor accuracy of the existing structural layer modulus inverse calculation Backcalculation and poor feasibility of the asphalt pavement structure bearing capacity evaluation system.

The evaluation results of the bearing capacity of five kinds of pavement structures in the test pavement are consistent with the pavement performance, which indicates that the evaluation method of the bearing capacity of asphalt pavement based on dynamic deflection equivalent is reasonable and effective.

References
[1] Ministry of Transport of the People's Republic of China. Highway performance assessment standard: JTG H20-2007 [S]. Beijing: China Communications Press, 2008.
[2] H.Scrivner,W.M.Moore, W.F.Mcfarland, and G.R.Carey. A Systems Approach to the Flexible Pavement Design Problem [R].Texas Transportation Institute, Texas A&M University System,1968.
[3] Uzan,J.,R.L.Lytton,F.P.Germann. General Procedure for Backcalculating Layer Moduli, STP 1026, ASTM.
[4] Rohde G.T, Scullion. T. MODULUS 4.0: Expansion and Validation of the MODULUS Backcalculation System. Research Repart,Texas Transportation Institute,1988.
[5] Wang Fuming, Liu Wenting. Research and application of pavement non-destructive testing and evaluation technology [M]. Beijing: Science Press, 1997.
[6] Ji Yigong, Wang Fuming, Guo Zhongyin. Backcalculation for layer moduli of pavements based on Falling Weight Deflectometer tests[J].China Civil Engineering Journal 2002,35(3):31～35.
[7] Tang Boming. Evaluation of pavement structure status [D]. Doctoral thesis of Southeast University, 1990.
[8] Huang Wei, He Ping. Analysis of deflection and compressive strain on the surface and subgrade of flexible pavement [J]. Chinese Journal of Geotechnical Engineering, 1998, 20(3): 26-31.
[9] Hee Mun Park. Use of Falling Weight Deflectometer Multi-Load Level Data for Pavement Strength Estimation [D].Ph.D. Dissertation,North Carolina State University, Raleigh,NC.2001: 33-38
[10] AASHTO, “AASHTO Guide for design of pavement structures”,Washington D.C.AASHTO, 1993.
[11] T. Paul Teng,P. E. Back-Calculation of layer parameters for LTPP test sections. Publication No. FHWA-RD-01-113, Washington, DC: Federal Highway Administration, September 1997.
[12] Zeng Sheng. Research on pavement performance evaluation and analysis method [D]. Doctoral thesis of Central South University, 2003.
[13] Zhi yufeng. Research on pavement construction quality assessment method based on deflection instrument [D]. Doctoral thesis of South China University of Technology, 2005.
[14] Liu Shaowen, Li Wenliang, Hu Xudong, etc. Research on LSAM design method and road performance of large particle size asphalt mixture [R]. Shanxi Academy of Transportation Science, 2011.
[15] Shen Jinan. Asphalt and asphalt mixture pavement performance [M]. China Communications Press, 2003