Analysis of Early Damage of Asphalt Pavement

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Abstract: This paper summarizes several kinds of asphalt pavement early damage type and discuss the reasons of every kind of damage, and analyzed the pavement design, site construction, the impact of pavement early damage. Through the analysis of the data statistics, computing, processing the vehicle loads on the impact of pavement damage.

Keywords: Asphalt pavement; The early damage; Vehicle load; Pavement design

1. Introduction

By the end of 2014, China's highway mileage reached 4.4639 million km, of which the total mileage of highway reached 112,000 km. Highway maintenance mileage of 4,353,800 km, accounting for 97.5% of the total mileage of the road. Why is there so much road maintenance, the answer is the premature emergence of damage to the road, now spent on the cost of road maintenance has been far more than our budget, we are building more roads, the future we spent on conservation The more costs. So the surface smooth, solid, seamless, driving comfort of the asphalt pavement why there is always early damage? This is a question worth pondering.

2. The Early Failure Type and Reason of Asphalt Pavement

Asphalt pavement common early damage phenomenon and the characteristics of asphalt pavement, the general situation is related to water, because the damage is generally occurred in the spring and autumn, after heavy rain or rain, because the road surface will first appear a small area of network crack, take slurry, and then The emergence of loose pulp or potholed areas; road lanes, especially the wheel marks at the damaged area more, and the damage is serious, can be seen with the vehicle overload. Through the analysis of the above asphalt pavement, asphalt pavement damage mode is divided into the following.

2.1. water damage and the causes

Asphalt pavement water damage is widespread, the use of more than one year will have different degrees of highway water damage. The only difference is that some highway water damage is serious, and some water damage is lighter. As time goes on, especially after long-term accumulation of rain, the road wheel at both sides of the road to push and uplift, water damage to the faster, the most serious nature, so it is the enemy roadbed. Precipitation into the asphalt surface, depending on the location of water retention, in a large number of high-speed vehicles under the action may have the following different situations of water damage: (1) surface layer of potholes. That is, the rainfall will enter and stay in the surface layer of asphalt concrete in the pore, in a large number of fast driving under the action of time and again generated hydrodynamic pressure (pore water pressure) so that the asphalt from the gravel surface peeling down, local asphalt concrete Into a loose, gravel wheel thrown, the road potholes. (2) the surface layer and the middle layer at the same time produce pits and local surface of the network crack and deformation. In the process of precipitation, such as free water infiltrated and stuck in the surface layer and the middle layer, a large number of fast driving makes the bitumen on the part of the asphalt concrete in the two layers peeling off, resulting in surface crack, deformation and pushing to the outside , Or create holes. (3) Tong pulp, net crack, pits occur at the same time. Such as water through the asphalt surface, stranded in the top of the semi-rigid base, in a large number of fast driving under the action of free water to produce a lot of pressure and erosion of the mixture surface layer of fine material, the formation of gray slurry, mortar is driving pressure to the road surface. Reason: Asphalt concrete itself air rate, the compaction degree is not enough and unevenness is the main cause of asphalt surface water damage, the main cause of asphalt pavement water damage is precipitation, traffic volume and traffic composition and traffic speed . In areas where precipitation is usually high, water damage is more severe than in semi-arid and arid areas where precipitation is small. Traffic volume and load vehicles and more highways than the traffic volume of small vehicles and less high-speed vehicles; more serious asphalt pavement water damage internal factors: the first type Ⅱ asphalt concrete air ratio and Ⅰ type asphalt concrete

compaction Degree is too small, the actual air rate on site is large, and the local air rate caused by uneven asphalt concrete is bigger. The second is the lack of adhesion of asphalt and gravel. Third, China's road design method is not used to consider the drainage layer of pavement structure and does not set an effective waterproof layer.

2.2. Trough and the causes

The trough is one of the main phenomenon of the asphalt pavement, the trough is generally in the high temperature season, the asphalt surface in the vehicle under repeated rolling and permanent deformation and plastic flow and gradually formed. It is usually accompanied by asphalt surface layer compression subsidence at the same time, the emergence of lateral bulge, the combination of the two constitute. Is defined as the asphalt pavement with the depression, in fact, serious trough at the same time, the track with depression, both sides of the asphalt concrete often heave, resulting in highway asphalt pavement groove.

The causes of trough are divided into internal and external causes. The strength and rutting resistance of asphalt concrete depends on the properties of the materials in the mix and their compositional gradation. The internal factors of forming trough are as follows: ①The quality of mineral aggregate usually requires the use of hard, wear-resistant, impact-resistant aggregate with good grain size close to the cube and no more than 15% of the flat long grain. ② Asphalt material properties, asphalt penetration and viscosity are two different indicators. The greater the penetration of the asphalt, the smaller the bond strength of the mixture, the worse the strength or the resistance of the asphalt mixture. The higher the viscosity of the asphalt, the greater the strength of the mix or the resistance to the trough. Asphalt temperature is the temperature of asphalt viscosity changes with the degree of change in temperature, such as the viscosity of asphalt to produce large changes in the asphalt temperature on the large, while the asphalt temperature sensitivity is small. The greater the temperature sensitivity of asphalt, the higher the temperature of the asphalt mixture of the weak bond, the ability to resist the trough the smaller the ③ mixture of the gradation and density, increasing aggregate particle size to improve its anti-rutting ability A certain effect, asphalt mixture determines the density of the mixture in the size of the porosity, the greater the density, the smaller the voidage, the mixture of anti-rutting tank capacity is stronger. The amount of asphalt, asphalt is a mixture of various sizes of mineral binder, it will be a variety of sizes of mineral aggregate together, after compaction to form high strength asphalt mixture. The actual situation is not as much as the amount of coated mineral aggregate asphalt film thickness, asphalt adhesive strength is large. Therefore, too much amount of asphalt will not only significantly reduce the internal friction of asphalt concrete, but also significantly reduce the cohesive force, the result is a significant reduction in the ability of asphalt concrete trough resistance. The formation of trough external factors are:①the number of heavy trucks and its axle load and tire pressure, the more the number of heavy trucks, axle weight and tire pressure the greater the easier the formation of trough, so the requirements of asphalt concrete resistance The greater the capacity; ② traffic speed, to bear the slow traffic or parking conditions of the road and bear the rapid traffic compared to the road, the former requires a large asphalt concrete anti-trough capacity, the slower speed requirements Asphalt concrete, the greater the resistance to trough. The asphalt concrete has a low elastic modulus due to its high temperature and high temperature.The stiffness of asphalt concrete decreases drastically with the increase of temperature④ Construction quality control is not strict, construction quality control is the key to the quality of asphalt after molding, the quality of the construction process more factors. Such as the type of construction equipment, vehicle conditions, the standardization of construction procedures, the driver's operational level will affect the final quality of the asphalt pavement.

2.3. Flooding and the causes

Highway asphalt pavement of the traditional oil-type phenomenon is defined as: the asphalt surface in the free expansion of asphalt, until the asphalt concrete voids can not accommodate, the phenomenon of overflow road table; new definition: road surface water intrusion surface and long-term stay At the bottom of the asphalt layer, the asphalt film on the aggregate surface peels off as free asphalt under the repeated action of driving load and dynamic pressure water scouring, and is forced to migrate to the upper part under the action of water, Loose asphalt migration phenomenon. With the past residue of the road surface oil phenomenon is significantly different. Asphalt pavement on the highway oil phenomenon is mainly produced in the traffic lane, over the lane of the phenomenon of little oil. The phenomenon of oil pan in the traffic lane is mainly intermittent and strip-like, and the distance is often greater than the length of the pan pan. Continuous flooding and the entire lane full of oil phenomenon is not much. In fact, each highway asphalt pavement has a phenomenon of oil pan, but the number and extent of the severity of the difference. Some sections of the severe and continuous oil pan, and some sections of the interval between the more serious flake-type medium oil and oil pan have. In recent years, the pavement of the SMA test section and the formal works also have varying severity of the phenomenon of oil pan. A section of a highway section of

the modified asphalt SMA also has the phenomenon of oil pan.

Excessive amount of asphalt is the most fundamental reason for the asphalt surface layer of oil, while the asphalt is too large for the main reasons: (1) asphalt mixture design is not enough. (2) construction control lax and mismanagement. Mineral aggregate gradients often change significantly, while the amount of asphalt remains constant. (3) a small number of construction units are accustomed to using a larger amount of asphalt mixture. In addition, the formation of the reasons for the formation of the mixture of oil and improper mix composition, mixture of asphalt too much or too little porosity, repeated in the role of vehicle load, the excess from the bottom to the formation of flooding asphalt road surface pan; Mixing mixture control lax, fine material content is too small, mixture of small surface area, the amount of asphalt more, but also prone to pan oil; viscous oil amount of improper spraying too much sprinkler uneven local will appear Flooding. The construction quality is poor, the mixture when the paving produces segregation, local fine material too concentrated, will also produce oil pan; rain infiltration to make the lower asphalt and stone peeling, under the action of water peeling off the film, the pan pan caused by oil pan.

2.4. Loose and the causes

Loose due to the asphalt concrete surface layer in the aggregate particles fall off from the surface of the progressive process of development, aggregate particles and coated with asphalt loss of adhesion between the phenomenon. Loose asphalt pavement is a common disease, the main symptoms of asphalt and asphalt aggregate in the role of adhesive force gradually decreased and disappeared under the vehicle load in the asphalt concrete surface layer was loose state, the surface layer of aggregate particles fall off, The thickness of aggregate loss from the sand, road wear, road surface Ma Ma, many micro-pit, surface peeling, poor appearance of the road, driving discomfort. If not treated in time, it will continue to develop from the surface down, resulting in the formation of potholes.

The reasons for loosening are as follows:

(1) Asphalt asphalt mixture less than normal, low asphalt ratio, making the bond between the asphalt and aggregate poor.

(2) The aggregate particles are covered with sufficiently thick dust to bond the bituminous film to the dust, rather than to the aggregate particles. The friction of the surface wears the asphalt film and causes the aggregate particles to fall off. This situation is mainly due to excessive aggregate mud caused by mud.

(3) Due to low temperature construction, compaction degree is too small, resulting in asphalt pavement internal voidage is too large, under the action of the vehicle load caused by loose asphalt pavement layer.

(4) asphalt concrete surface layer of local compactness is low, the need for high density to ensure that the asphalt mixture cohesion. If the compaction of the mixture is not enough, aggregate is easy to fall off from the mixture, loose serious road, such as the loss of material left in the pavement after a pothole surface, and there is sufficient depth of water, it may cause water drift Phenomenon and have security problems. The surface of the loose aggregate will reduce the anti-skid ability, and was driving tire from the lane in the lane, causing other problems.

(5) loose water damage, due to the dynamic load of the wheel, the water gradually penetrate the interface between the asphalt and aggregate, the gradual loss of adhesion of asphalt adhesion, asphalt membrane from the aggregate surface, asphalt mixture Out of grain, loose.

1.5. Transverse cracks and the causes

Transverse cracks are the most common type of asphalt surface cracks. Transverse fractures are divided into load-bearing and non-load-bearing fractures. Load-bearing cracks are due to improper road design and poor construction quality, or as a result of severe overloading of vehicles, resulting in asphalt surface or semi-rigid base layer tensile stress exceeds its fatigue strength and cracks, each asphalt pavement road and each asphalt pavement expressway There are more or less horizontal cracks, non-load-bearing cracks are mainly asphalt surface temperature shrinkage cracks and reflective cracks in the grassroots. Horizontal cracks are also often seen as one of the early destruction of asphalt pavement.

Causes of transverse cracks:

(1) the construction of cold joints are not handled properly, seams are not close, with bad.

(2) Asphalt does not meet the local climate conditions and the use of the required quality standards, low temperature deformation resistance is poor, resulting in asphalt surface shrinkage cracking at low temperatures.

(3) Asphalt pavement surface thickness is insufficient, under the action of the traffic load to produce structural cracks. Thicker surface does not mean that the less the temperature cracks, under the same conditions in other conditions the thicker surface, the surface temperature stress may be greater, so the greater the possibility of temperature cracks, the more serious the situation.

(4) semi-rigid base shrinkage cracks produced by reverse cracks.

2.6. Longitudinal cracks and the causes

Longitudinal fractures are generally characterized by long straight fractures that are generally parallel to the mid line of the road and are sometimes accompanied by a small number of joints. Longitudinal slit caused by uneven settlement of sub grade is usually intermittent

and long. The vertical seam is caused by the poor construction. The longitudinal seam is caused by the lack of structural bearing capacity. Slope side of the road edge. According to the degree of damage can be further divided into two types of minor and serious, minor cracks in the edge of no peeling or only a slight peeling, no seam or only a small number of joints, serious cracks in the edge of a moderate or serious peeling,

The causes of longitudinal cracks: (1) consolidation of the foundation deformation. Before the embankment is filled, there is no load on the foundation, and the foundation is in equilibrium. Once the embankment is filled with the foundation, the foundation is subjected to the effect of dead load, and the higher the embankment is, the bigger the dead load is. 1m high embankment to allow the foundation to bear the constant load often up to 17kN / m^2 ~ 18kN / m^2 or more, plus the dead load so that the balance of the original state of the foundation has been destroyed. The foundation soil gradually deforms under the constant load of embankment until it reaches a new equilibrium state. The size of consolidation deformation is related to the height of fill, and the nature of each layer of soil within the foundation. Even non-soft ground, in the case of large soil compress , in about 10m high embankment under the action of the resulting consolidation deformation may be as high as 50cm or more. (2) consolidation of the embankment deformation. The size of embankment consolidation deformation is closely related to the height of soil, soil properties and compactness. Usually the soil is not good, the embankment consolidation deformation may be large; soil compaction degree is too small, the embankment consolidation deformation is large; the higher the embankment, the total consolidation deformation variable is greater. Increasing the compaction degree of subgrade can reduce the consolidation deformation of embankment and increase the strength and stability of roadbed.

2.7. Boil and cause

Frosting refers to the base of the powder, fine slurry from the surface layer of cracks or porosity from the porosity of the surface layer of precipitation, the road after the rain was pale gray.

The causes: (1) improper use of grass-roots or mixing uneven, fine material too much. Because of its poor water stability, softening after water, the role of water in the driving under the run. (2) low-temperature seasonal construction of semi-rigid base, the intensity of growth is slow; and open road traffic is too early, in the traffic and rain under the action of the primary surface of the powder, the formation of slurry. (3) frozen areas of grass-roots, winter water accumulation of ice, thawing in the spring when the boil. (4) Asphalt surface layer thickness is thinner, the porosity is larger, because not set under the sealing layer and did not take structural layer drainage measures to promote rainwater infiltration, doubling the formation of boil. (5) surface treatment and penetrating surface completion of the initial stage, the number of small driving role, the structural layer has not yet reached the density should be the rainy season, so that water seepage, grass-roots boil.

2.8. Possession and causes

Enclosed refers to the direction along the road or horizontal emergence of local uplift. Ownership of the package is more likely to occur in the vehicle often start, brake places, such as parking, intersections and so on.

Reasons: (1) asphalt mixture of high or fine asphalt content is high, thermal stability is not good. In the summer when the temperature is high, not enough to resist the horizontal force caused by traffic. (2) the surface layer of paving, the bottom is not clean or not sprayed asphalt layer of asphalt, resulting in poor adhesion on the road surface; asphalt paving uneven, local fine material concentration. (3) the base or the bottom layer without sufficient compaction, strength is insufficient, the deformation displacement occurs. (4) in the routine maintenance of the road, the local section of too much asphalt, fine aggregates or uneven paving. (5) steep slopes or poor road segment, the surface layer of asphalt mixture is easy to drive under the action of the accumulation of low to form a package.

3. Design of the Impact of Asphalt Pavement Damage

1) In recent years, with the large-scale construction of highway in China, the design time is also very urgent, the owners of units usually require design units in a very short period of time to pay design results, it is likely to cause design research is not enough, resulting in asphalt pavement There are many unreasonable design at the time, mainly include the following: unreasonable structural design, improper selection of asphalt surface structure, mixture type is unreasonable, according to asphalt pavement design specifications in addition to the asphalt surface should meet the requirements of the use of vehicles , Should also meet the requirements of the rain does not seepage, should use smaller particle size, gap is also a small gradation mixture, as far as possible the use of small particle size asphalt concrete to improve the impermeability of asphalt pavement surface. For the selection of medium-grained concrete or open-graded or semi-open graded asphalt pavement asphalt pavement, asphalt surface layer must be set under the seal layer to prevent rainwater infiltration.

2) The design of pavement thickness is a problem. The thickness of pavement design is based on the cumulative equivalent axle of the design year. In order to calculate convenience, the design unit divides the traffic volume of the designed road into the standard traffic volume of a

certain model and the non- Standard traffic volume, and then determine the model of the non-standard car axis, converted into the standard vehicle equivalent axis times, and then the design of the equivalent axis of the number of years to calculate the road design deflection and structural thickness, after a lot of road observation that: The actual axle load of the vehicle is much larger than that of the design axle load, but it is calculated by the equivalent axle load. In addition, the axle load of the standard car is larger than that of the standard axle load, especially the non-standard axle load. Formula, the equivalent axis times and the ratio of 4.35 power is proportional. It can be seen that the equivalent axial length of the designed pavement is far greater than the cumulative equivalent axle length in the design life of the design pavement. So it is the crux of the early destruction of new pavement at this stage.

3) Pavement, grass-roots, sub-base drainage design is ill-considered, and now the drainage design is usually arranged on both sides of the longitudinal ditch roadbed, rarely taking into account the road surface drainage design, surface water damage to the road surface is very serious of.

4) The specification can not meet the requirements of the present traffic. At present, the design road surface in China adopts a unified design specification for asphalt pavement. However, China is a country with a subtropical climate, monsoon climate and sub-cold climate. The temperature can reach minus 30 degrees Celsius, but in the south of the winter temperatures rarely fall to zero, and our rainfall from southeast to northwest is decreasing, the southeast wet and rainy year round, and in northwestern Inner Mongolia, Gansu, Xinjiang, where the rainfall Is very small, for such a large difference in climate, we take the same specification asphalt pavement design is clearly unreasonable. China's existing norms of the shortcomings of our norms is still a lack of low-temperature anti-cracking, semi-rigid base material frost content. In the north, due to the semi-rigid base material in the design of frost resistance performance indicators, in the construction control has not taken corresponding measures, so there is a semi-rigid base material freeze-thaw damage phenomenon. ② Asphalt mixture design parameters still remain in the field of elastic mechanics, has begun some research there are some shortcomings. (3) The design method is based on the theory of layered elastic system of pavement, which is based on the repeated damage of the vehicle load, which determines the design life of pavement, that is, the design method of durability. However, the actual road surface after 5 years or so will be destroyed, this time the road can not be seen as a complete elastic system, so the original durability design deviation.

4. The Effect of Vehicle Load on Early Damage of Asphalt

The current international road freight is to focus on the rapid development of the transport industry, this demand to stimulate the automotive industry to the heavy. The development of the train, you can put the ultimate development of road freight situation as rail freight. Bicycle load capacity significantly increased to more than 30t, at the same time in order to meet the growing load requirements, heavy-duty vehicles from the previous bias tire to rigid, load-bearing radial tires, Increase, from the previous 0.5-0.7MPa, increased to 0.8MPa, and even some more than 1.0MPa. With the continuous development of China's economy, transport vehicles in large-scale vehicles continue to increase. And vehicle overload phenomenon occurs, due to vehicle overload, resulting in early damage to the road, so that greatly shorten the life of the road, resulting in a greater economic losses and adverse effects. Therefore, we should pay attention to this problem.

Vehicle overload in the end of the destruction of asphalt pavement how serious? In the following, the influence of overload on the pavement is shown by calculating the equivalent axle loads after overloading.

According to China's existing "Highway Asphalt Pavement Design Code" in the axle load conversion formula

$$n_i = \sum_{i=1}^{k} C_1 C_2 N \left(\frac{P_i}{P}\right)^{4.35}$$

N-The equivalent axle load of the N-standard axis

n_i -Number of axle loads at all levels of the converted model

P-Standard Axle Load

P_i - Axle loads for all classes of converted models

C_1 - Number of axes

C_2 - The wheel set factor is 6.4 for a single wheel set, 1 for a two wheel set, and 0.38 for a four wheel set.

It is assumed that the standard axle load equivalent axle of a double-wheel set standard axle load 100KN automobile is 1000 times (shaft spacing less than 3m, two axes).

Table 1 shows the number of axle loads carried on 100-KN, 150KN, 200KN, 250KN, 300KN, 350KN, 400KN according to the calculation.

TABLE I. **Table 1. Overloaded vehicles equivalent axis table**

P_i (KN)	120	150	200	250	300	350	400
P	120	100	100	100	100	100	100
N	1000	1000	1000	1000	1000	1000	1000
C_1	2	2	2	2	2	2	2

C_2	6.4	6.4	6.4	6.4	6.4	6.4	6.4
n_i	4420	11668	40786	107663	237962	465292	831746

From the calculated table can be clearly seen, when the overload reaches 2 times the number of axle load is the standard axle load times 40 times, when the overload to 4 times, the number of axle load is the standard number of axle load more than 800 Times, overload several times the growth, resulting in a few hundred times the number of shaft load increase, the following line through the line more clearly the performance of this exponential growth.

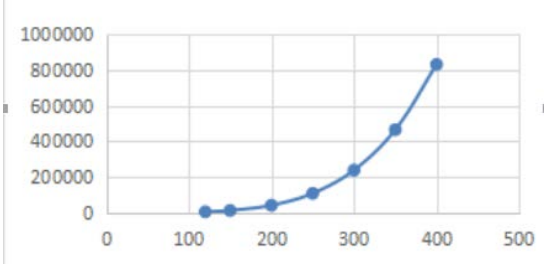

Figure 1. **Figure 1. Overloaded equivalent axis line chart**

This shows that overload damage to the road surface is very large, but the phenomenon of overload, we have done a survey, a toll station truck overload ratio in Table 2.

TABLE II. **Table 2. Toll station overload situation**

project	Vehicle Type								
	small truck			Middle truck			big truck		
	No load	Semi-real load	overload	No load	Semi-real load	overload	No load	Semi-real load	overload
Actual number	9	4	18	25	15	88	7	3	32
proportion	29	13	58	10	12	69	17	7	76

Can be seen from the table data, the phenomenon of overloading the current truck is very often See, each model is more than 50%, especially large trucks, the proportion of overload is reached 76%, but the truck overload into the standard number of axle load index is growing, the page that is, adding the original The design of the road axle load is n times, the design life of the road is 10 years, then under the influence of overload, the road surface in the use of 2 years after the cracks, rutting these damage.

5. Influence of Construction on Early Damage

Construction of the early destruction of asphalt pavement is also a very big factor. For the standard 25cm asphalt pavement, once its construction jerry-building, even if the reduction of 1cm, will make the life of the road by one-third, this effect is enormous. While the construction of the degree of compaction is not enough, poor raw materials, serious segregation can cause early damage to the road.

5.1. Compression is not enough to cause early damage

This situation often occurs in soft soil foundation, in the process of roadbed construction, the degree of compactness control is not good, in the horizontal uneven easily lead to road surface cracking, serious re-cracks formed 1 ~ 2cm of the cracks, affecting the traffic Comfort and safety.

5.2. Early damage caused by poor raw materials

China's current highway asphalt pavement using a variety of sizes of gravel are from a number of quarry on the market procurement, because the domestic large quarry less, most of the stone from the self-employed mining stone factory, the scale Small, backward equipment, lack of quality control the necessary means. In the purchase of stone when the boss is to see a sample of high-quality stone, but in the actual large-scale use, due to the tight schedule of heavy tasks, had to use other types of machines produced by blending the use of stone. Which resulted in a variety of non-uniform specifications of the pavement material, needle sheet exceeded.

5.3. Severe segregation caused by early destruction

Improper construction caused by pavement surface segregation can also cause early damage to the road, such as an isolated water damage caused by the network crack, deformation, pits, local severe rutting oil. When the mixture segregation, coarse aggregate and fine aggregate are concentrated in a certain position of the pavement layer, so that the asphalt concrete is not uniform, the mix proportion and the amount of asphalt are inconsistent with the design, resulting in local porosity increasing, Asphalt concrete surface, the water stay in the asphalt concrete surface layer, under the action of vehicle load generated hydrodynamic pressure, so that from the aggregate surface peeling off, resulting in early damage to the road.

6. Conclusion

Early destruction of asphalt pavement is not simply caused by overloading, nor because the construction is

not up to standard, affecting the early destruction of asphalt pavement is a combination of many factors, even from the outset we have a problem, this goes back to laboratory measurements Various parameters start. Site paving conditions and laboratory conditions vary widely, so the laboratory data in the end how much the reference value is easy to determine the make up. Under the conditions of construction rainfall, temperature, light can not be simulated in the laboratory. In short, from the beginning to obtain the data, to the road design, to construction, and then to the actual use of the road when the uncertainties are affecting the early destruction of the road.

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