Table 2.1: Marshall mix criteria

(a) Maximum and Minimum Values			
Marshall Method Mix Criteria	*Light Traffic ESAL < 10^4 (see Chapter 19)*	*Medium Traffic 10^4 < ESAL < 10^6 (see Chapter 19)*	*Heavy Traffic ESAL > 10^6 (see Chapter 19)*
Compaction (No. of blows each end of Specimen)	35	50	75
Stability *N* (lb)	3336 (750)	5338 (1200)	8006 (1800)
Flow, 0.25 mm (0.1 in.)	8 to 18	8 to 16	8 to 14
Air Voids (%)	3 to 5	3 to 5	3 to 5

(b) Mineral Percent Voids in Mineral Aggregates	
Standard Sieve Designation	*Percent*
No. 16	23.5
No. 4	21
No. 8	18
⅜ in.	16
½ in.	15
¾ in.	14
1 in.	13
1½ in.	12
2 in.	11.5
2½ in.	11

SOURCE: Federal Highway Administration, U.S. Department of Transportation.

2.6 Pavement Types

In general, there are two types of pavement structures: flexible pavements and rigid pavements. There are however, many variations of these pavements types, including some with soil cement and stabilized bases that have cemented aggregate. Composite pavements (which are made of both rigid and flexible layers), continuously reinforced pavements, and post-tensioned pavements (pre-cast) are other types, which are usually, require specialized design and are not covered in this stage.

As with any structure, the underlying soil must ultimately carry the load that is placed on it. Having mentioned that a pavement function is to distribute the traffic load stresses to the soil (sub-grade) at a magnitude that will not shear or distort the soil. Typical soil-bearing capacities can be less than 345 kPa and in some cases as low as 14 to 21 kPa. When soil is saturated with water, the bearing capacity can be very low, and in these cases, it is very important for pavement to distribute tires loads to the soil in such a way as to prevent failure of the pavement structure. Figure 2.6 shows a difference in stress distribution through flexible and rigid pavements.

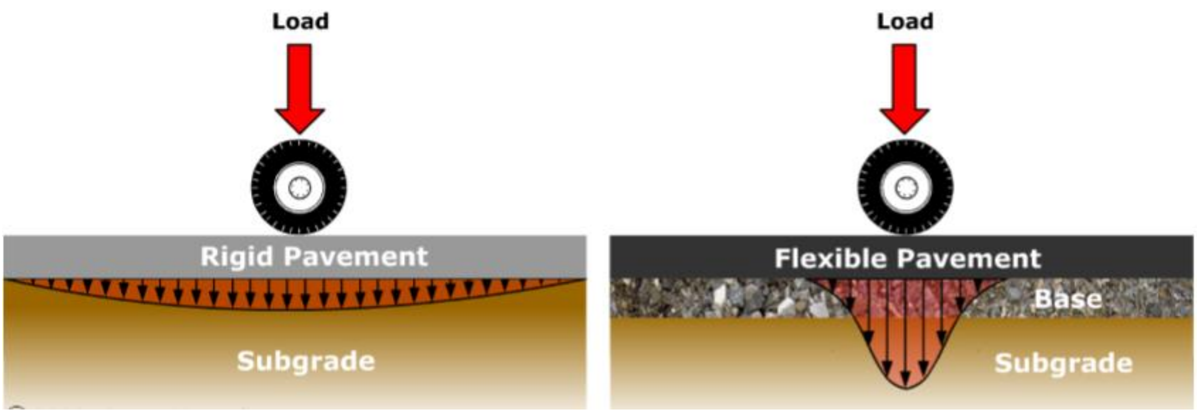

Figure 2.6: Stresses distribution under rigid and flexible pavements

In general, Table 2.2 illustrate the key points difference between flexible and rigid pavements while Figures 2.6 and 2.7 show the structure layers of flexible and rigid pavements respectively.

Table 2.2: Key points difference between flexible and rigid pavements

Flexible Pavements	***Rigid Pavements***
It consists of a series of layers with the highest quality materials at or near the surface of pavements	*It consists of one layer Portland concrete slab or relatively high flexural strength*
It reflects the deformation of sub-grade and subsequently layers on the surface	*It is able to bridge over localized failures and area of inadequate support*
Its stability depends upon the aggregate interlock, particles friction and cohesion	*Its structural strength is provided by the pavement slab itself and by its beam action*
Pavement design is greatly influenced by the sub-grade strength	*Flexural strength of concrete is a major for design*
It functions by a way of load distribution through the component layers	*It distributes load over a wide area of sub-grade because of its rigidity and high modulus of elasticity*
Temperature variations due to change in atmospheric conditions do not produce stresses in flexible pavements	*Temperature changes induce heavy stresses in rigid pavements*
It has self-healing properties due to heavier wheel load and therefore it is recoverable in some extent	*Any excessive deformations due to heavier wheel loads are not recoverable. For example, settlements are permanent*

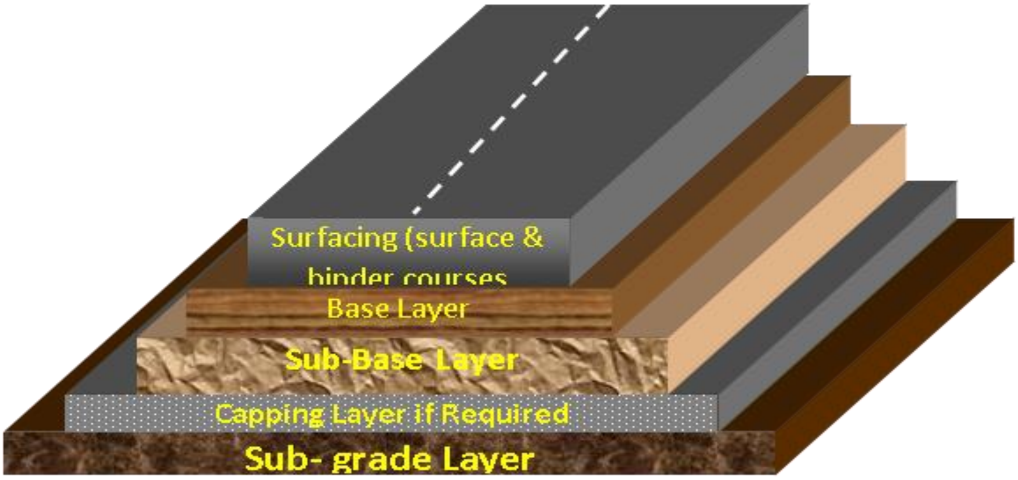

Figure 2.6: Typical structure of flexible pavements

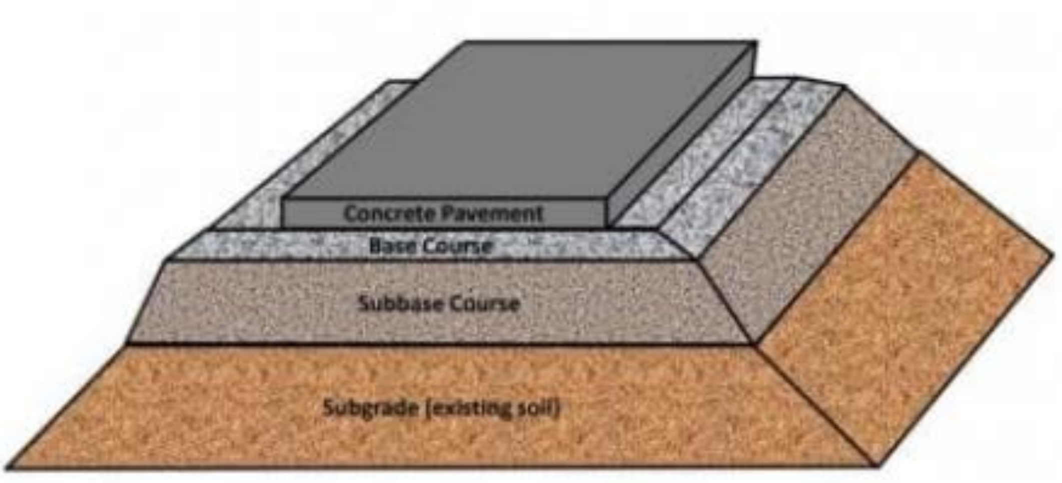

Figure 2.7: Typical structure of rigid pavements

2.6.1 Flexible Pavement

2.6.1.1 Types of Flexible Pavement

The following types of construction have been used in flexible pavement:

- Conventional layered flexible pavement.
- Full - depth asphalt pavement.
- Contained rock asphalt mat (CRAM).

Conventional flexible pavements are layered systems with high quality expensive materials which are placed in the top where stresses are high, and low quality cheap materials are placed in lower layers.

Full - depth asphalt pavements are constructed by placing bituminous layers directly on the soil sub-grade. This is more suitable when there is high traffic and local materials are not available.

Contained rock asphalt mats are constructed by placing dense/open graded aggregate layers in between two asphalt layers. Modified dense graded asphalt concrete is placed above the sub-grade will significantly reduce the vertical compressive strain on soil sub-grade and protect from surface water.

2.6.1.2 Typical layers of Flexible Pavement

Typical layers of a conventional flexible pavement includes seal coat, surface course, tack coat, binder course, prime coat, base course, sub-base course, compacted sub-grade, and natural sub-grade. Figure 2.8 shows typical flexible pavement structure.

Seal Coat:

Seal coat is a thin surface treatment used to water-proof the surface and to provide skid resistance.

Tack Coat:

Tack coat is a very light application of asphalt, usually asphalt emulsion diluted with water. It provides proper bonding between two layer of binder course and must be thin, uniformly cover the entire surface, and set very fast.

Prime Coat:

Prime coat is an application of low viscous cutback bitumen to an absorbent surface like granular bases on which binder layer is placed. It provides bonding between two layers. Unlike tack coat, prime coat penetrates into the layer below, plugs the voids, and forms a water tight surface.

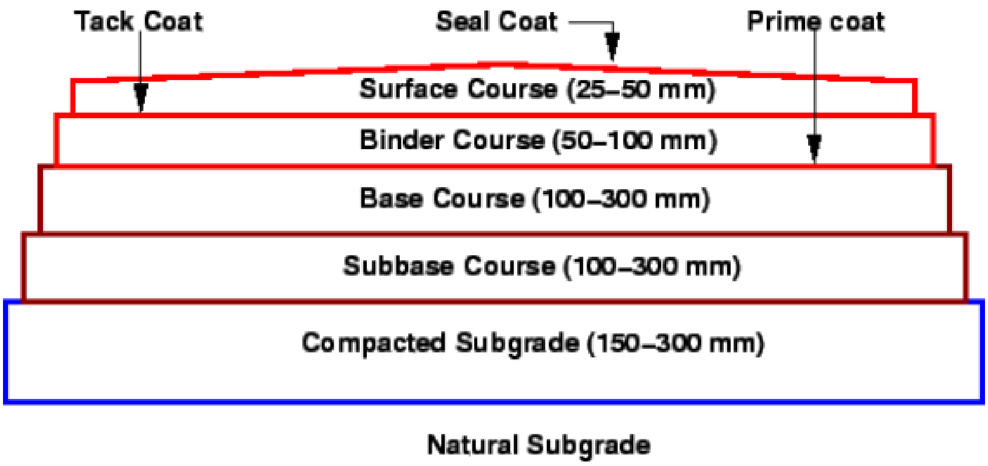

Figure 2.8: Typical flexible pavement structure.

Sub-grade:

The subgrade is usually the natural material located along the horizontal alignment of the pavement and serves as the foundation of the pavement structure. It also may consist of a layer of selected borrow materials, well compacted to prescribed specifications. It may be necessary to treat the subgrade material to achieve certain strength properties required for the type of pavement being constructed. Soil stabilization is the treatment of natural soil to improve its engineering properties. One solution to enhance the properties of sub-grade is to stabilize this layer. Soil stabilization methods can be divided into two categories, namely, mechanical and chemical. This can be achieved using one of these methods below;

1. ***Cement-stabilized soil*** is a mixture of water, soil, and measured amounts of Portlandcement—thoroughly mixed and compacted to a high density and then allowed to cure for a specific period, during which it is protected from loss of moisture.
2. ***Soil cement*** is a hardened material obtained by mechanically compacting a mixture of finely crushed soil, water, and a quantity of Portland cement that will make the mixture meet certain durability requirements.

3. ***Cement-modified soil*** is a semi hardened or unhardened mixture of water, Portland cement, and finely crushed soil. This mixture has less cement than the soil–cement mixture.
4. ***Plastic soil cement*** is a hardened material obtained by mixing finely crushed soil, Portland cement, and a quantity of water, such that at the time of mixing and placing, a consistency similar to that of mortar is obtained.
5. ***Soil-lime*** is a mixture of lime, water, and fine-grained soil. If the soil contains silica and alumina, pozzolanic reaction occurs, resulting in the formation of a cementing-type material. Clay minerals, quartz, and feldspars are all possible sources of silica and alumina in typical fine-grained soils.

Sub-Base Course:

The sub-base course is the layer of material beneath the base course and the primary functions are to provide structural support, improve drainage, and reduce the intrusion of fines from the sub-grade in the pavement structure. If the base course is open graded, then the sub-base course with more fines can serve as a filler between sub-grade and the base course. A sub-base course is not always needed or used. For example, a pavement constructed over a high quality, stiff sub-grade may not need the additional features offered by a sub-base course. In such situations, sub-base course may not be provided.

Base Course:

The base course is the layer of material immediately beneath the surface of binder course and it provides additional load distribution and contributes to the sub-surface drainage. It may be composed of crushed stone, crushed slag, and other untreated or stabilized materials.