added.
The bitumen aggregate mixture is cooked for 6 - 8 hours, once it is ready to
use, the item is carried to the work site to layer.

• **High modulus asphalt concrete:** This uses a very hard bituminous asphalt in proportions close to 6% of its aggregates, to create an asphalt concrete layer with a high modulus of elasticity of 13000 Mpa, as well as high fatigue strengths.
They tend to
exhibit a greater capacity of absorbing tensions and better fatigue resistance.

How roads deteriorate?

Different types of asphalt have different performances characteristics in terms of surface
durability, tire wear, braking efficiency volume of traffic and roadway noise.

• **Common terminologies used:**
Alligator cracking: Thin/ weak surface of road and poor drainage

• **Block Cracking:** Usage of old and dried out mixture of asphalt and gravel. Sometime cracks are occurred with low traffic.

• **Edge cracks:** Frost heave, Vegetation along edge.
Linear/Longitudinal cracks: Shrinkage of asphalt layer.

• **Reflection cracking:** Deterioration under heavy traffic.

• **Slippage cracks:** Vehicular turning or stopping in pavements with a low surface mix. In sufficient bonding between surface layer and base layer, due to dust, oil, dirt, rubber,
water and other non-adhesive material.

• **Corrugations & Shoving:** Excessive moisture in the base layer. Low air voids. Fine
aggregate content too high in asphalt
Pot hole: Poor surface mixture,

thawing of a frozen subgrade, cracking, a failed patch
after pieces of the original pavement.
Fiber Reinforced Asphalt:
Asphalt containing a mixture of discrete fiber improves and increases the structural integrity of the asphalt.
The filers are distributed uniformly and randomly oriented maintaining a pattern to strengthen the asphalt concrete overall. Only 3% percentage of
fibers is introduced to the asphalt mixture to act effectively.

• **Effects of Fiber in Asphalt:**
-Fibers control the cracking due to plastic shrinkage.
-Reduce the bleeding of water.
-Improves thaw resistance.
-Improves resistance to explosive spalling in case of a severe fire.
-Improves impact resistance and abrasion resistance.
-Reduces crack widths and control the crack widths tightly, thus improving durability.
-Increases the tensile strength.
-Reduces air voids; water voids the inherit porosity of gel.
-It has been recognized that the addition of small, closely, spaced and uniformly dispersed fibers to concrete would act as crack arrester and would substantially
improve its static and dynamic properties.
Methods used for introducing the filers in Asphalt mixture:

• **Dry Mix Process:** The dry process mixes the fiber with the aggregate before adding asphalt. The dry process allows for the best fiber distribution in the mixture. It also reduces the clumping
or balling of fibers in the mixture.

• **Wet Mix process:** The wet process blends the fibers with the asphalt prior to incorporating the binder into the mixture.

• **Different Fibers used in Asphalt**:
Elastomer and Plastomer Polymers: Polymers are useful modifiers for the improvement of adhesivity, tensile strength greater improvement of stiffness of Asphalt concrete.
Rubber elastomers are used in the place where is desire to reduce cracking or thermal cracking and extending the service of
the road.

•**Polypropylene Fibers (PP):** Polypropylene fibers are used widely as reinforcing agents in the concrete. It gives three-
dimensional reinforcement to the Asphalt concrete, making it more durable and tough.
So, these Polypropylene fibers are used as a modifier in asphalt concrete.

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Asphalt Fibers

Asphalt Concrete: The term Asphalt Concrete is referring to the liquid asphalt portion of the composite material. It is commonly called as Asphalt, blacktop or pavement in North America and Tarmac or Bitumen in Great Britain.

A composite material used to surface roads, consists of mineral aggregate bound together with asphalt laid in layers and compacted.

• Roadbuilding process:

> Clearing: The first thing done in roadbuilding is to clear the obstructions that disturbs the pathway, like the tress, rocks, loose sand and etc., using off-road/heavy vehicles.

> Levelling: The next important step is levelling the ground. Removing large chunks of rocks and compensating it by adding sand or gravel.

The base layer of fine levelled soil is layered about 9 inches' height.

> Materials added: Now the mixture of gravel and molten Asphalt is layered above the well levelled ground/pathway. Coarse gravel is layered about 6 inches' height and another mixture of crushed gravel mixed with molten asphalt are layered on top of about 4 inches height.

It is then pressed down by a road-roller to improve adhesive strength and good levelling for the vehicles to run smoothly.

• Conventional Asphalt and aggregate mixing methods:

Hot mix Asphalt concrete (HMA):

This is produced by heating the asphalt binder to decrease its viscosity and drying the aggregate to remove moisture from it prior to mixing.

Mixing is generally done at 300 °F for virgin Asphalt at 330 °F.

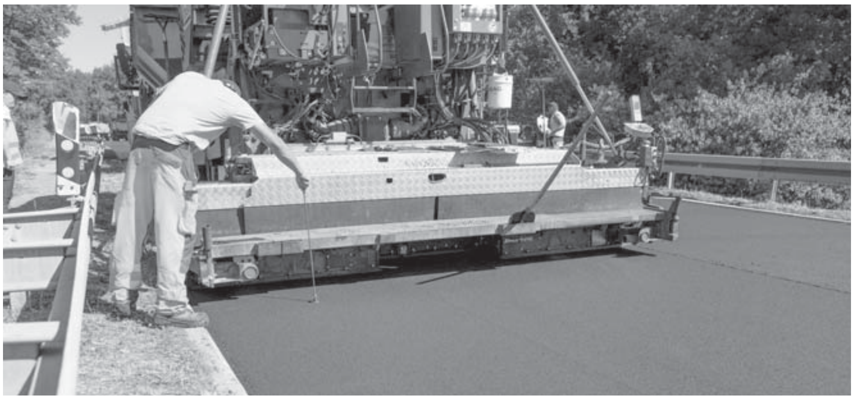
Paving and compacting must be done while the asphalt is sufficiently hot itself or else the asphalt will change into solid state which will become hard to compact/smooth it.

• Warm mix asphalt concrete (WMA): This is produced by adding zeolites or waxes which allows significantly lower mixing and laying temperatures and results in lower consumptions of fossil fuels thus releasing low CO_2 aerosols and vapors.

• Cold mix Asphalt: This is produced by emulsifying the asphalt in water prior to mixing with the aggregate.

It is less viscous when emulsified and the mixture is then easy to work with. It is often used in path works.

• Mastic asphalt concrete: This is produced by heating hard grade blown bitumen/asphalt in a mixer until it has become a viscous liquid after that the aggregates are



Resulting less crack intensities on the road, slightly stiffer and improved fatigue life, it was not remarkable. The biggest problem encountered by the PP fibers is the inherent incompatibility with hot asphalt binder due to low melting point of fiber.
So, PP fiber of 3mm length by the total dosage of 3% modifying bitumen were used in the wet mix process, resulted the best FRAC samples.
The mixing rate (gyration) and temperature were 2h at 500rpm and 163 °F.
In this condition the stability of the road increased by 20%. Concluding PP fibers are effective only used in controlled temperature blending of asphalt mixtures.

• **Polvester Fibers:** Polyester is the polymerized product of component from crude oil.
This fiber is better than polypropylene fibers because of its high melting point.
The viscosity of the asphalt binder increased with increasing polyester fiber contents, at low temperature. To achieve uniform distribution throughout the asphalt concrete, the fibers must be mixed with the aggregates at the beginning of the dry mix cycle which last about 15 and preferably 30 seconds, in the required proportion.

• **Asbestos Fibers:** Asbestos fibers were used as a non-synthetic fiber in pavements.
Cotton fibers and asbestos fibers were used but these are degradable on the long run and not allowed for reinforcements since it has health hazards.

• **Cellulose fiber:** Fibers made up of esters of cellulose got from the bark of tree. It has similar properties as of the engineering fibers. This mixture allows asphalt contents to be increased while drastically decreasing bleeding of the binder; no changes were seen on abrasion of the asphalt.

•**Carbon Fiber:** Carbon fibers offers more advantages than other fiber types for the modification of asphalt binder. Since the fibers are composed of carbon and asphalt, both is hydrocarbons, they are inherently compatible. Carbon fibers are manufactures at high temperature (1800 °F), melting is not a problem as the melting point of asphalt is also high.
It is hypothesized that carbon fibers should be most compatible, best performing fiber type available for modification of asphalt binder. Carbon fiber has the capacity to resist the structural distress in road, improve fatigue by increasing resistance to cracks or permanent deformation. Therefore, adding carbon fiber to asphalt mixture will improve some of the mechanical properties of the mixture. Carbon fibers are produced from poly acrylonitrile or pitch precursors. Most importantly Carbon fibers are the most expensive fibers among other fibers.

• **Glass Fiber:** Glass fiber has high strength; its elongation is 3-4% and its elastic recovery is 100%. Glass fibers will not burn easily.
They will soften at 1499 °F and their strength begins to decline above 599 °F.
Glass fiber added to asphalt mixture enhances material strength and fatigue characteristics.
The use of glass fiber reinforced asphalt mixtures may increase the construction cost, as glass fibers are expensive.

•**Nylon Fiber:** The use of asphalt concrete samples fabricated with fibers of 1% volume and the length of 12mm results in 85% higher fraction energy than non-reinforced specimens showing improved fatigue cracking

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