

Research Article

## Novel Technique of Laying Bitumen Roads Using Light Detection and Ranging [LIDAR]

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### Abstract

*With the rise of the 20th century, due to rapid rise in industrialization, it became necessary to create marketing and transport facilities. To provide these facilities, heavy vehicles were required. These heavy vehicles increase pressure on roads. The industries are constantly searching for novel technological improvements to enhance the strength of material's used for road construction, increase efficiency and conserve resources. So, here through this paper I present before you the perfect solution for all the problems.*

**Keywords:** LIDAR (Light Detection and Ranging), Bitumen (petroleum product).

### Introduction

In India, rapid growth in urbanization has rapidly increased growth of industrial and service sectors resulted in rapid growth of heavy laden vehicles in limited road space. So this made it necessary to develop new technologies, to develop new laws to be followed while making roads, to increase their life and strength, to withstand high stresses with minimum maintenance. The 10% increase in truck weights increases in the stresses applied to the pavement by 40% and is further affected by heavy traffic and change in weather conditions.

Now while speaking about whether condition a factor which must to be considered is the widespread boundaries of India. Indian boundaries extend from west corner of Gujarat and East corner of Arunachal Pradesh. And from north corner of Jammu and Kashmir to south corner of Tamil Nadu. Due to this reason the climatic condition of India varies from place to place. Due to this reason, the laws used for making roads are not applicable everywhere, neither the machines used to do so can be used efficiently at all places. The environmental aspects compel the Indian road congress and national highway department to reform the maintenance budget every year.

This affects the economy of India and also creates problem in its implementation.

So the need is to come up with an ultimate solution to this entire problem. This solution need to be a multidisciplinary one, involving proper study of material used and requirement of most efficient machine to use it.

For doing something it's not just the technique but also the choice of proper raw material. For construction of roads 'tar' was used, but the fumes released were too harmful for environment and also they were very carcinogenic for humans. As safety is one of the important aspect this tar was replaced by 'bitumen' which is a petroleum product obtained by refining of crude petroleum.

Now for the use of bitumen there was need for classification of bitumen for using it precisely for a specific purpose according to the properties of material required for that purpose. In India this was done by Bureau of Indian Standards. BIS introduced paving grade bitumen specifications (IS: 73-1950) in the year 1950 for the first time, the classification was done on basis of penetration. They were revised in the years 1962 and 1992. But still there was chance to improve the quality of Bitumen, so BIS revised IS-73-1992 specifications based on Viscosity (Viscosity at 60°C) in July 2006. As per these specifications, they were classified as four grades VG-10, VG-20, VG-30 & VG-40. Each viscosity grade has some specific properties which decide its use. Their specifications are as follows:

**VG-10 BITUMEN:** VG-10 is generally used for spraying applications such as surface-dressing of roads or they can be used for paving in very cold region

**VG-20 BITUMEN:** VG-20 is used for paving purpose but in cold climate & high altitude regions

**VG-30 BITUMEN:** VG-30 is primarily used to construct Bitumen pavements for heavy duty traffic to withstand

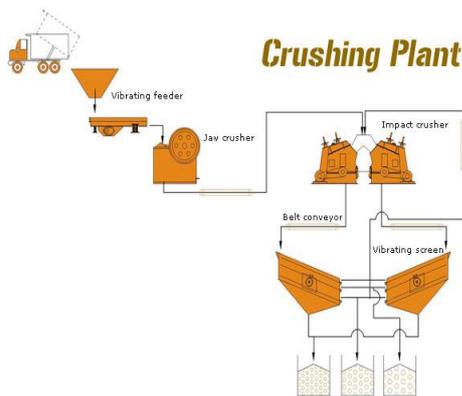
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substantial traffic loads, at temperature range 25°C to 60°C (which is temperature range in India).

**VG-40 BITUMEN:** VG-40 is used road construction in highly stressed areas of extremely high traffic generally seen near toll booths and truck parking areas.

So the best grade of bitumen suitable for construction of roads in India is Bitumen grade VG-30, and also this is the reason why government of India has banned the use of tar and made it compulsory to use this VG-30 grade all over India.

Now when material to be used is known then there comes the process to be followed to do so. In case of construction of these bitumen roads there is requirement of crushed stones. These are obtained from stone mountains. They are broken then its huge pieces are brought to factory having huge machines to crush them. During crushing, these stones have to go through a number of processes. They are dropped on vibrating feeder then they are passed through jaw crusher. Further they are transported to impact crusher and then to belt conveyer. Finally to vibrating screen and then required sizes of crushed stones are obtained as shown in figure-1 below. Fine aggregate of stones obtained may be completely crushed or naturally occurring material, or a combination of both. It shall be clean, durable and having enough strength. Also it should be free from dust and other soft organic substances.



**Figure 1:** Crushing plant

The second material used is the bitumen which is obtained from refining of crude petroleum. There is need to produce required viscosity of bitumen as we cannot vary its viscosity during construction by adding thinners or by adding solidifiers. Once material is obtained then comes the process.



**Figure 2:** Bitumen stone and liquefied bitumen

For construction of bitumen roads huge machines are required. There is requirement of huge trucks to transport these materials to construction site then there is requirement of machines for mixing of different materials then paving them on rough pavement using proper machines. Also another case is possible which is generally seen in India. The bitumen is transported in the form of blocks and also the crushed stones are transported separately. Then at site they are heated either manually by workers or by some small scale machines laid on road. Then using rollers they are levelled and thus the roads are constructed.



**Figure 4:** Road construction machine



**Figure 5:** Manual construction of roads

While following these processes there are some drawbacks:

- 1) India cannot afford huge road construction machines everywhere as their cost is very high.
- 2) When done manually precision reduces.
- 3) Fumes released are harmful for humans and environment.
- 4) When bitumen is heated manually on site (done in India) proper temperature range of melting of bitumen cannot be maintained.
- 5) Most of the time proper mixing of bitumen and crushed stones is not possible thus lowering the quality of roads made.
- 6) Requirement of longer time span and road closure.

- 7) No machine available for repairing of damaged roads.

So this leads us to development of novel technique of 'LIDAR Road Paver'



For CAD Model of LIDAR Road Paver refer to, <http://bit.ly/2isqknC>

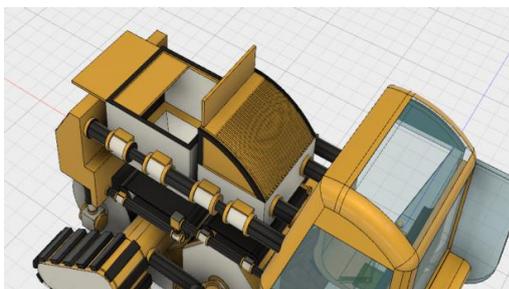
This is the design of a machine I have created using CAD software Autodesk Fusion 360. The idea behind making this model was to create a mechanism for a machine which can perform tasks which can be done presently by different machines.

Presently, there are different machines for performing every single step while construction of roads. There is need of a heating unit to keep bitumen in molten state, separate machine is required to store crushed stones and bitumen separately and transporting them to the construction site. A mixture is required to properly churn and mix both the materials before paving. Generally, it's not done anywhere but if we wish to reuse the old paved asphalt there is requirement of a machine having milling tool attached to it to remove old paved asphalt. The most important while using these machines is, we have to use number of machines, remember and follow a proper sequence while using them. Also these machines require large space so the cost of machines is also high.

LIDAR Road Paver is a compact machine which can do all the work done by all above machines even better than them, more efficiently, more precisely and then too more economically.

Before explaining the working of machine and how to use it, need is to know the parts used in the machine. They are:

- 1) *Asphalt Container and Bitumen Container.*

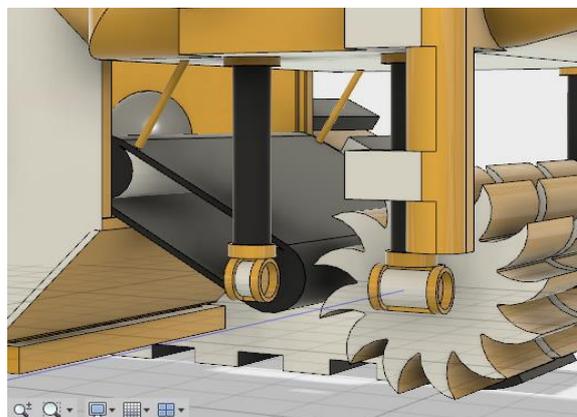


The machine has separate containers for storing crushed stones and bitumen separately. These

containers can be filled as done in other machines i.e. from upside, but for removing the material there are gates provided at the bottom for outflow of material.

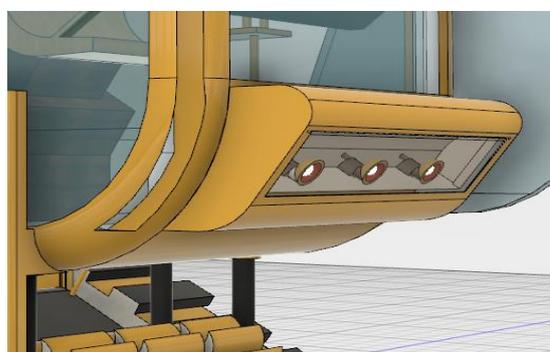
These gates are precisely controlled by height sensors placed inside the containers. As we know volume = area x height, so by varying height outflow of material can be precisely controlled. Also there are heaters inside bitumen container for keeping bitumen in molten form which is necessary for paving.

- 2) *Milling tool and Inclined Belt*



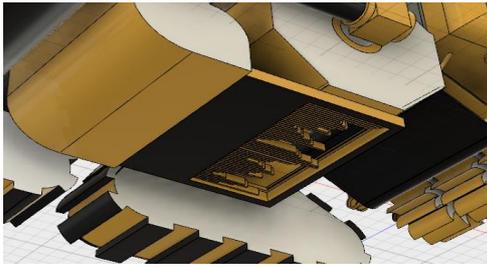
- 3) The milling tool is placed at the bottom front of the paver. It is useful for removal of old paved asphalt which is of no use but can be reused using LIDAR Road Paver. At the side of it is an inclined belt. The removed material is loaded on the belt and transported to the mixing container. The belt can be pulled up or released down using some chain or piston whichever comfortable.

- 4) *LIDAR Sensors*



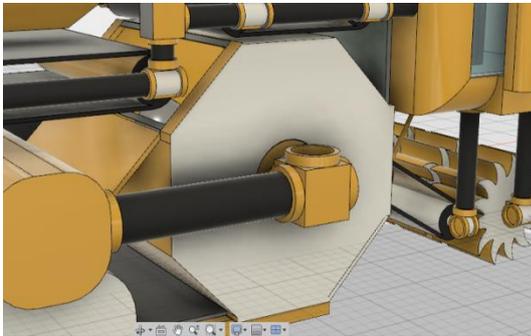
The LIDAR sensors are placed in front of the paver to scan the surface of road in front of it to measure the depth of pit or pothole in the road. Then the sensors create a computerised map of the land profile which is used to know the amount of material to be laid on path for construction of roads. These sensors are the most innovative part of the machine which is not used anywhere yet. This increases the precision of making roads. If the roads are precisely made, they will last long and will be more efficient for transportation purpose.

### 5) LIDAR Controlled Gates.



These gates are placed at the bottom of the paver and controlled using the LIDAR sensors. The sensors scan the surface and the data is given to the gates. According to the data provided the gates open precisely and only required amount of material flows out of the container on the pavement. At the place of pothole of larger depth, more material is laid and at the place of small pothole less material is laid out thus maintaining precision in work.

### 6) Asphalt and Bitumen Mixer



The asphalt and bitumen container is the place where the bitumen and crushed stones are mixed together. It has three doors. One is near the milling tool for intake of old asphalt for reuse. Second is up for taking in the bitumen and crushed stones from their separate containers. The third is at the bottom which is connected to the LIDAR controlled gates. This third gate is the place from where the new material to be paved comes out. The mixer rest on ball shaped structures which rotates the mixer and thus ultimately mixing the material inside then container.

### 7) Driver Cabin



The above figure shows the driver's cabin. It is made with anti gayer glass and also it is self adjustable in sunlight, lowlight and even in dark. The seat for driver is made of soft cushion with adjustable height according to the requirement. The doors of cabin open on both sides and both of them are sliding to save space if they are used to open sideways. The work of driver inside cabin will be,

- To drive the paver.
- To start the LIDAR scanning.
- To open and close the door while adding material in paver.

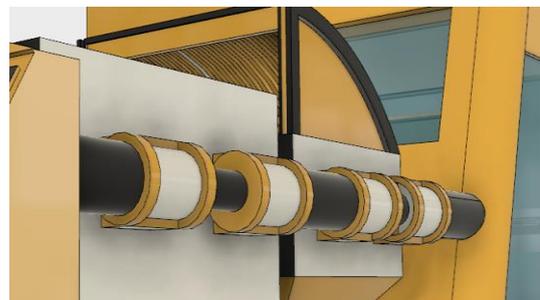
All other operations are automatic.

### 8) Rolling Belts



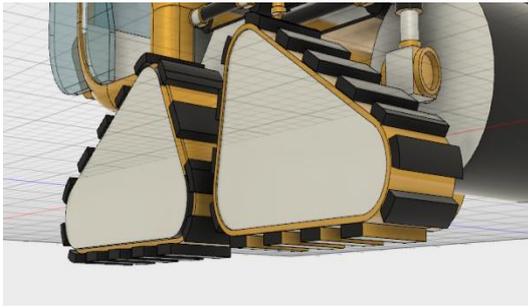
The machine uses belts to transfer material from one part of machine to another. They are made of long lasting and strong material to withstand the weight of stone aggregates. Also they are chosen such that they sustain certain required temperature of the bitumen which is transported using these belts. Most important reason for using the belts is that they can be easily replaced when they wear out.

### 9) Couplings



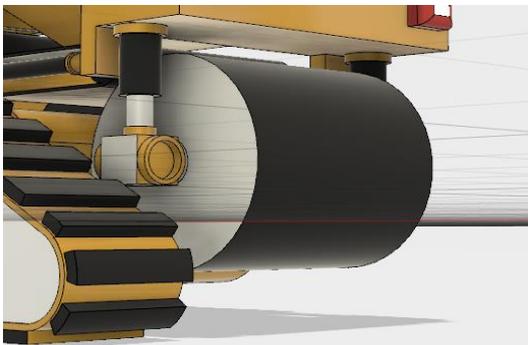
For any road paving machine most important requirement is to separate its parts easily and easily join them. This is necessary because, the melted bitumen gets solidified and sticks in corner of the containers. So in this machine arrangements are made to separate the parts easily using special couplings which are never been used in any machine before. They are more long lasting, cost efficient and even easy to dismantle and clean

### 10) Articulated Crawlers



These are special type of crawlers which can be used in the machine. The speciality of these wheels is that, like tyres of truck they can move fast and without noise and like wheels of tank, they can move on any surface. Thus this machine can be used for paving roads in any type of land and in any part of country, may be plateau region or a hilly region.

### 11) Roller

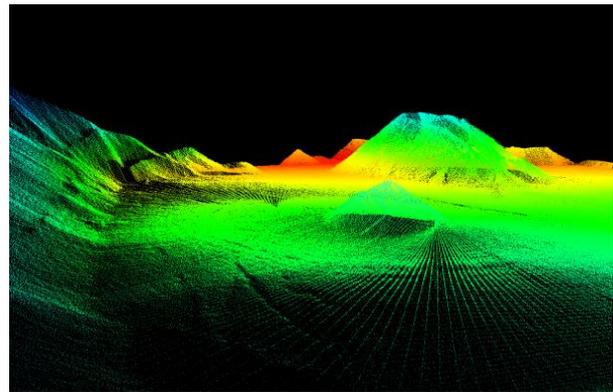


Like any road paving, the work of this LIDAR Road Paver will end with levelling of road. This will be done with the help of rollers attached at the back part of the machine. The special thing with them is that, in case of other machines these rollers always touch the ground, make noise and also decrease speed of vehicle but here the rollers are lifted up or moved down according to the need. For this purpose there are pistons attached to them to control them efficiently and precisely according to the need.

Along with the use of best possible parts in machine there is need of making proper sequence for their work so that the output obtained is according to our requirement. So here is the working of 'LIDAR Road Paver'.

- 1) The paver will be behind the pothole on road at initial stage.
- 2) The LIDAR scanners placed in front of the paver scan the road surface.
- 3) The scanned data is collected and computerised map of the road profile is created.
- 4) This map of road profile created helps in deciding further working process of the machine.
- 5) According to the requirement the milling tool attached in front of paver are lowered.

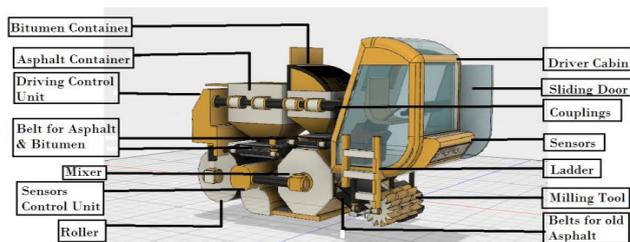
- 6) The work of milling tool is to remove previously laid asphalt from road, collecting it and loading it on the inclined belt near it.
- 7) This inclined belt end up in the mixing unit.
- 8) The removed material is moved to mixer and the process stops at the end of pothole.
- 9) During this process the paver once move over the pothole.
- 10) Now the inclined belt are lifted up and the side door of mixer is closed.
- 11) During this process the paver moves back to its initial position.
- 12) Now again the LIDAR sensors are operated and the scanned surface data is collected.
- 13) Now a computerised map is created of the pavement before material is mixed and put on road.



**Figure 17:** Computerised Mapping of Land Profile Scanned by LIDAR Sensors

- 14) Using this data the volume of material required is calculated.
- 15) This required volume is divided in volume of bitumen required and volume of aggregates required for proper paving mixture.
- 16) The area of material's containers is known, so the amount of material outflow is controlled using the height sensors inside the containers.
- 17) Accordingly the bottom gates of containers open and using the rotating horizontal belt below each container the materials are put in mixer.
- 18) During this process the upper door of mixer is open and it closes as soon as the required material is taken in.
- 19) The bitumen and stone aggregates taken in container are properly mixed and asphalt for paving is ready.
- 20) Now the data of LIDAR Sensors is given to the gated below the mixing container.
- 21) The gates open accordingly leading to precise amount of material outflow.
- 22) During this process the paver moves over the pothole for second time, but this time the pothole is no longer empty.
- 23) Behind the paver the roller is moving over the paved road to level.

Thus the road paving process completes using LIDAR Road Paver.



**Figure 18:** Complete LIDAR Paver structure along with labelling

**Conclusions and Discussion**

The use of LIDAR Road Paver for construction of roads increases precision in work.

- Decreases labour cost.
- Enables use of new and advance technology.
- Efficiency of work increases.
- Lesser requirement of road closure.
- Saves time
- Proper and efficient use of paving material reduce its wastage
- More cost efficient
- Due to low cost, can be used even in remote corners of country.

- No requirement of using many huge machine as LIDAR Road Paver can do all the work in single machine structure.
- Proper maintenance of temperature of bitumen.
- Less or almost no release of harmful fumes
- Environment friendly
- Not harmful for human health in any manner.
- Can be used for construction of new roads and even for repairing of old ones.
- Thus good for all!

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 Image 4 reference: Modern Road Construction in France and Germany: Equipment, Technology, Materials in Frankfurt, Metz and Paris  
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 Image 6-16 reference: Screenshot images of different views of LIDAR Road Paver  
 Image 17 reference: Surveying and mine management using mobile LIDAR scanning Dynascan M250.