# CHOICE OF BITUMINOUS OTTA SEAL SURFACING AN ECONOMIC PAVEMENT SURFACING FOR LOW VOLUME ROADS

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***ABSTRACT***

*Providing reliable road access to remote areas is a challenge for many countries. Earthen and gravel surfaces are commonly used on low volume roads. This article discusses the construction and use of otta seal, a low cost road pavement to improve reliability and serviceability of unpaved and low traffic roads. Its advantages and disadvantages are discussed based on its application in Nepal where its performance is still under evaluation.*

***Key Words:*** Otta seal, road pavement, Nepal

## INTRODUCTION

Road pavement surface provides driving space to vehicles using the road. It is desirable that a riding surface should be smooth enough to not cause jerking and jolting to the vehicles and its passengers. At the same time, it is desirable that the surface be skid-resistant. Pavement carries the wheel loads of vehicles and transfers the load to the sub-grade soil through various structural layers. The loads are transferred through the wheels of vehicles via contact pressure.

### *Types of Pavement*

Mainly there are two types of pavement:

1. Flexible Pavement
2. Rigid Pavement

For the present, this article is dealing with flexible pavement surfacing. Flexible types of pavements have low flexural strength and are flexible in their structural action under the wheel loads. The flexible pavement layers reflect the deformation of the lower layers on to the surface layer. This means that when any layer of the pavement underneath is undulated, the surface becomes undulated as well. The flexible pavement layers transmit the vertical compressive stresses to the lower layers by grain to grain transfer through the points of contact in the granular structure. The flexible pavement usually has the following components and layers.

### *Different layers in flexible pavement*

- Sub-grade
- Selected fill, capping layer or improved sub-grade
- Sub-base
- Base course or road base
- Surfacing

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### *Sub-grade, selected fill, capping layer or improved sub-grade*

The sub-grade is a layer of natural soil prepared to receive the layers of pavement materials placed over it. It essentially consists of local natural soil or existing material or transported fill. It is well compacted in order to achieve the required strength. Weight loads on the pavements are ultimately absorbed by the soil sub-grade. The overlain layers have a function of distributing the load so as not to overstress the sub-grade beyond the limit. Therefore, it is important that the sub-grade be well compacted before adding other layers. Sometimes, if the strength of the sub-grade soil is very weak, a separate layer of reasonable strength will be paced and well compacted. This additional layer is referred to as selected fill, a capping layer or improved sub-grade.

### *Sub-base*

Sub-base is a load distributing layer above the sub-grade and usually consists of

- Unprocessed natural gravel
- Gravel Sand
- Gravel sand clay

This layer serves as a separating layer, for overlaid road base and prevents contamination of the base course by sub-grade, material. Its other important function is to protect damage to the sub-grade caused by construction traffic.

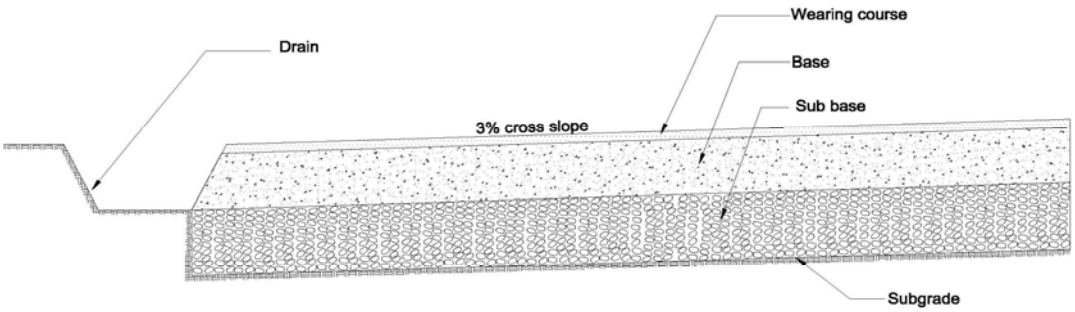
### *Base Course or road base*

This layer acts as main the load spreading layer for the pavement by absorbing wheel loads of vehicles plying on the pavement. It consists of crushed stone, gravel, gravely soil, decomposed rock, sand and sand clays stabilized with cement, lime or bitumen.

### *Surfacing*

This is an uppermost layer of pavement and consists of a bituminous material in the form of surface dressing, Otta Seal, or a layer of pre-mixed bituminous material. Sometimes premixed materials are applied in two layers and are referred to as the base course and the wearing course for the lower and upper layers respectively. A typical cress-section of the flexible pavement is as shown in the following figure.

**Figure 1. Typical cross section of flexible pavement**




## I. SURFACING OF ROADS

Gravel roads are generally maintained as low cost roads in developing countries. In dry conditions, dust generated by traffic results in increased gravel loss which causes dust pollution. This can create safety hazards and discomfort to road users and can adversely affect agricultural yields the health of livestock. Dust pollution can contaminate food stores and water resources, which are susceptible to airborne dust concentration. Dust also reduces the life of electrical equipment. During wet seasons, there will be a high rate of gravel loss due to flooding and substantial surface water. This will necessitate re-grading and the laying of additional gravel. However, gravel roads are seldom maintained systematically. Lack of maintenance, often causes gravel roads to revert to earthen roads. These uneven roads can deprive communities of access to necessary services, creating serious social implications. In developing economies in order to seal gravel surfaces the following criteria must be met.

It should be:

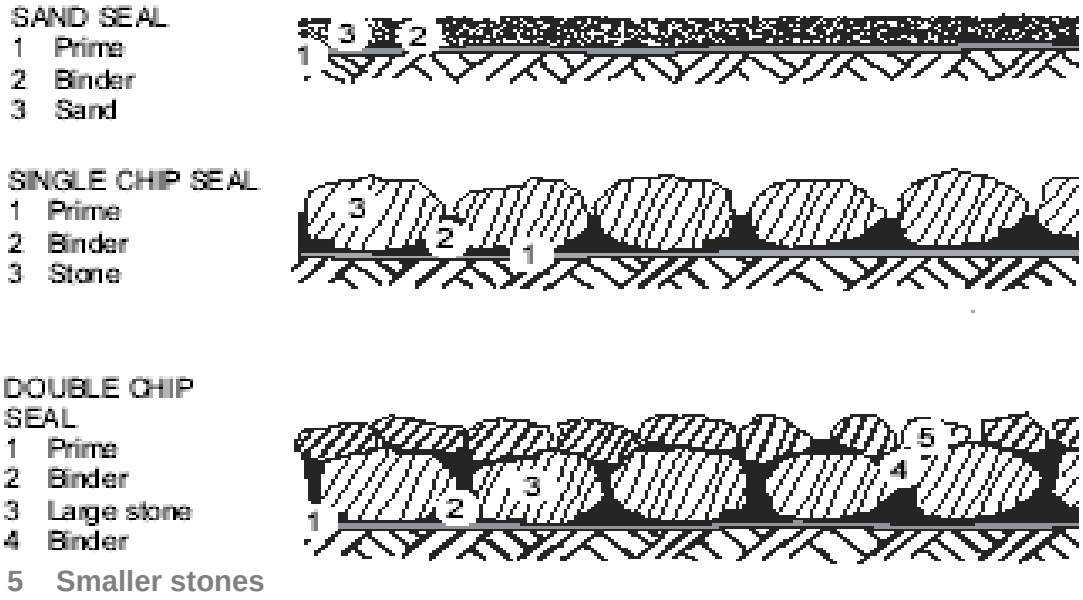
- Cheap
- Constructed with locally available aggregates
- Impervious
- Flexible
- Durable

Although gravel surfaces can be sealed in a variety of ways, the following three methods are the most common:

- Sand Sealing,
- Single Chip sealing and
- Double Chip sealing

These types of sealing techniques are shown in the Figure 1. The first illustration shows sand sealing with the help of a binder applied to the sand first, while the second and third illustrations show the sealing of pavement using stone aggregates, with a binder being applied once and twice respectively.

**Figure 2. Type of sealing**




In the above figures the gravel surface is first primed with cut back bitumen, a layer of hot bituminous binder is then applied and the surface is sealed with materials spread on the surface and rolled out.

### *Function of Bituminous Surfacing*

The major functions of the bituminous surfacing are:

- To provide durable, tight impervious surfacing which seals and protects the underlying pavement layers from moisture, and the resulting pavement degradation;
- To provide a skid-resistant surface that is resistant to abrasion and disruptive forces caused by traffic and other environmental factors;
- To prevent the formation of corrugation, dust and mud;
- To permit relatively safe travel at higher speeds; and
- To lower vehicle operating and maintenance costs.

### *Types of sealing*

Various types of bituminous surfacing with different characteristics and service lives have been developed for application in specific situations depending on factors such as, type and volume of traffic, type of pavement and environmental conditions.

In flexible pavement construction, the following types of sealing are in practice.

a) Single or multiple surface dressing
b) Seal Coat
c) Slurry seal
d) Sand seal
e) Otta seal
f) Semi –grouting + Seal Coat/Wearing course
g) Premixed asphalt concrete

### *Choice of Otta seal surfacing*

Otta seal is a thin bituminous seal comprised of graded gravel or crushed aggregate of all sizes and either cut-back or soft penetration grade bitumen with or without a sand cover seal. The first Otta Seal Surfacing was created in Norway in 1963-65 as an experimental innovative approach to sealing gravel roads in a cost effective manner. The outcome was much more effective than originally expected and resulted in approximately 12,000 km of the roads in Norway to be resurfaced in 1999 using Otta seal.

A number of roads in Nepal in recent years have been constructed using Otta Seal surfacing. The product's performance is now being evaluated. The approach of surface dressing has long been practiced in Nepal, but using Otta Seal is a relatively new practice. Nepal began using Otta Seal in 2002. Currently, the total length of roads in Nepal that have been sealed using Otta Seal is estimated to be above 1000 km. Some examples of locations where Otto seal is being used in current road construction include Surkhet-Jumla, Surkhet-Dailekh and Basantapur-Tehrathum road in Nepal. An observation of the recently completed Surkhet–Jumla road indicated an improvement in the roughness index and in ride quality (NASC, 2011). The success of Otta seal depends upon sound construction, good workmanship and careful preparation of the area to be sealed. Failure to properly prepare surfaces as well as poor workmanship can be misinterpreted as a design failure. In terms of cost. Otta seal is less expansive than other bituminous pavement such as surface dressing, penetration macadam, and asphalt concrete. Use of Otta seal can prevent surface gravel loss and reduce air born dust, and can therefore benefit the environment as well as the lives of people living in the influence area.

Otta seal is different from surface dressing in that a graded gravel or crushed aggregate containing all sizes, including filler, is used instead of single sized-chippings. There is no formal design procedure but recommendations based on case studies have been published (Norwegian Public Roads Administration, 1999). Otta seal may be applied in a single or double layer. Evidence on the performance of these types of seal has shown them to be satisfactory for over 12 years on roads carrying up to 300 vehicles per day (Overby, 1999).

1. Single Otta Seal
   - With sand cover seal
   - Without sand cover seal

2. Double Otta Seal
   - With sand cover seal
   - Without sand cover seal

Aggregate grading can be "open", "medium" or "dense", depending upon availability, economy and engineering properties.

Graded aggregate is placed on a relatively thick film of comparatively soft binder. As a result rolling and trafficking, the binder works its way upwards through the aggregate interstices. In much the same was a bituminous premix does, the graded aggregate relies both on mechanical interlocking and bitumen binding for its strength.

The material requirements for Otta seal construction are provided in tables 1 through 3.

**Table 1. Choice of binder for Otta Seal**

| **AADT at Construction** | **Type of bitumen for different aggregate grading** | | |
|---|---|---|---|
| | **Open** | **Medium** | **Dense** |
| >1000 | NA | 150/200 pen | MC 3000<br>MC 800 in cold |
| 100 – 1000 | 150/200 pen | 150/200 pen in cold | MC 3000<br>MC 800 in cold |
| <100 | 150/200 pen | MC 3000 | MC 800 |

**Table 2. Binder application rate Lit/m$^2$**

| | | **Grading of aggregate** | | |
|---|---|---|---|---|
| | | **Open** | **Medium** | **Dense** |
| Double | 1st Layer | 1.6 | 1.7 | 1.8 |
| | 2nd Layer | 1.5 | 1.6 | 2.0 |
| Single with a Sand Cover Seal | Fine Sand | 0.7 | 0.7 | 0.6 |
| | Coarse sand | 0.9 | 0.8 | 0.7 |
| | 1st Layer | 1.6 | 1.7 | 2.0 |
| Single | | 1.7 | 1.8 | 2.0 |
| Maintenance Reseal | | 1.5 | 1.6 | 1.8 |

**Table 3. Aggregate grading requirement**

| Sieve sizes (mm) | Open grading (per cent passing) | Medium grading (per cent passing) | Dense grading (per cent passing) |
|---|---|---|---|
| 19.0 | 100 | 100 | 100 |
| 16.0 | 80 - 100 | 84 - 100 | 93 - 100 |
| 13.2 | 52 - 82 | 68 - 94 | 84 - 100 |
| 9.5 | 36 - 58 | 44 - 73 | 70 - 98 |
| 6.7 | 20 - 40 | 29 - 54 | 54 - 80 |
| 4.75 | 10 - 30 | 19 - 42 | 44 - 70 |
| 2.0 | 0 - 8 | 3 - 18 | 20 - 48 |
| 1.18 | 0 - 5 | 1 - 14 | 15 - 38 |
| .425 | 0 - 2 | 0 - 6 | 7 - 25 |
| .075 | 0 - 1 | 0 - 2 | 3 - 10 |

## II. CONSTRUCTION PROCEDURES

***Preparation for Otta sealing:***

Otta seal will not add to the structural strength of a road. For this reason, the surface to be treated must previously have been prepared to withstand the expected traffic levels. Preparation of the road base may include regravelling, reshaping and compaction. Immediately prior to the application of Otta seal, the road base must be broomed to keep the surface free of sand and excess dust, mud or any other material that might hinder bonding between the seal and the road base. Priming the road base with non-calcareous material is not normally required. Calcareous material does require priming due to its capacity to absorb high amounts of bitumen. MC 30 or MC 70 is normally used for priming and is applied at spray rates between 0.8 and 1.2 $l/m^2$. Therefore, calcareous road base material should not be used, as it requires priming before the use of Otta seal.

Stockpiles of aggregate must be inspected to determine whether screening is needed to remove excess fine or overly large particles. The spreading of aggregate should be carried out by either conventional mechanical or labour intensive methods. If aggregate is to be spread by hand then small stockpiles must be placed in sufficient quantities at ten metre intervals on either side of the road to be treated, but at sufficient distance from the road so as not to interfere with the binder spraying operation.

The procedure for applying Otta seal is outlined below:

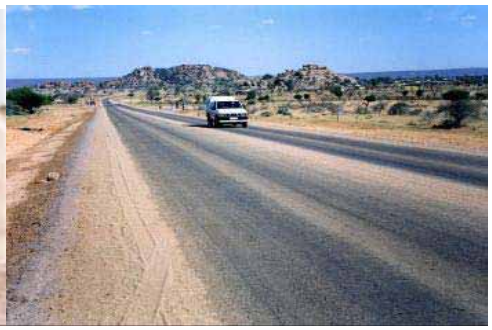
1. The area of road to be treated must be marked out by some means such as with string or small stones. This will ensure the correct placement of the binder and aid in avoiding possible overspray onto adjoining verge side areas.
2. Controls must be put in place to prevent the encroachment of traffic into the treated area. The binder distributor should be loaded with sufficient

binder to complete the work area. The binder should be maintained at the proper temperature for optimal spraying.

3. Cut-off sheets of paper or other material must be placed across the road at the start and end of the length of road to be sprayed. This produces a tidy appearance.
4. Check repeatedly and maintain the appropriate speed with the distributor in order to produce the correct binder spray rate.
5. Check the quantity of aggregate being placed and ensure that the workforce is ready to follow the distributor and spread the aggregate in order to maintain a correct spread rate.
6. Check that the rolling equipment is positioned and ready for rolling.
7. It is recommended that the distributor makes a spray run of 100 meters to allow for immediate covering of the binder with aggregate. Rolling can begin within 10 minutes of the binder being applied.
8. Spreading of the aggregate must begin immediately after the spraying of the binder has begun. The binder must be covered with aggregate as soon as possible.
9. The supervisor must ensure that no areas are left uncovered or that too little aggregate is spread. Aggregate must not be left in heaps. A drag broom, pulled manually or by tractor, can help ensure even distribution before rolling begins.
10. Twelve ton pneumatic-tyre rollers must be used in the application of Otta seal although it is possible to use loaded trucks in their place. The section of treated road may be reopened to traffic after 3 passes of the rollers but on the day of construction, the treated surface must receive a minimum 15 passes.
11. Traffic must be restricted to speeds of no more than 30 kilometres per hour for two to three weeks after construction in order to minimize the hazard of excess aggregate being thrown into the air.
12. During this initial period, aggregate displaced by the action of traffic should be swept back into the wheel paths. After 2 to 3 weeks, excess aggregate should be swept away and the traffic speed restriction can be lifted.
13. If a second layer is to be applied to create a double Otta seal, then a minimum of 2 to 3 months should pass before the application of the second layer.

Photographs 1 through 8 and figures 3 and 4 show Otta seal application as well as the various types of Otta seal surfacings that have been used in Nepal. There is, however, another type: double Otta seal. Otta seals can also be applied in combination with more traditional seals such as sand.

**Photograph 1. Binder distributor** **Photograph 2. Completed Otta seal**



**Photograph 3. Base course being prepared just before the application of Otta seal**

**Photograph 4. Binder being sprayed by distributor over the freshly compacted Base**

**Photograph 5. Aggregates being sprayed by hand over the freshly sprayed binder by distributor**

**Photograph 6. Rolling process being carried out by pneumatic tyred roller**

**Photograph 7. Rolling process being carried out by a pneumatic tyre roller from edge to centre**

**Photograph 8. Finished Single Otta seal surface seen after the opening of traffic over the base course**

**Figure 3. Single Otta seal**

**Figure 4. Single chip seal (Surface dressing)**

***Performance Characteristics***

The performance of Otta seal depends on a number of factors which include:

- Type of Otta seal (texture, durability etc.);
- Bearing capacity of the pavement; and
- Traffic using the road.

**Table 4. Comparison of advantages and disadvantages of Otta seal**

| | Advantages | Disadvantages |
|---|---|---|
| 1 | Easier in construction and quality control | Initial inconsistent and somewhat patchy appearance; |
| 2 | Allows maximum use of local materials | Bleeding, in some cases, giving erroneous impression that something is wrong; |
| 3 | Longer service life | Need to consider a number of additional contractual issues |
| 4 | Allows use of low strength aggregate | |
| 6 | Better weather protection when used with sand seal | |
| 7 | Suitable to labour intensive construction | |

## CONCLUSIONS

The article outlines the design and application of Otta seal, a low cost pavement for low traffic roads. The types of Otta seal, the materials required, steps for preparation and its application procedures are described. Based on limited experience on its use in Nepal, its advantages and disadvantages are compared. Though it is gaining popularity, further evaluation and assessment of its performance would enhance its wider application on low volume roads.

## REFERENCES

Khanna, S.K. and Justo, C.E.G. (1984). *Highway Engineering*. 5th ed. Roorkee, Uttarakhand, India: Nem Chand & Bros.

Overby, Charls (1999). *A Guide to the Use of Otta Seals*. Publication no. 93, Directorate of Public Roads, Road Technology Department, International Division, Norway. Oslo: Allkopi AS.. Available from www.vegvesen.no/_attachment/194703/binary/378864.

Transport Research Laboratory (1993). A guide to the structural design of bitumen-surfaced roads in tropical and sub-tropical countries. Overseas Road Note 31. 4th ed. Crowthorne, Berkshire: TRL. Available from www.transport-links.org/transport_links/filearea/publications/1_716_Microsoft Word - Overseas Road Note 31 edit1.pdf.

Transport Research Laboratory (2000). A guide to the surface dressing in tropical and sub-tropical countries. Overseas Road Note 3. 2nd ed. Crowthorne, Berkshire: TRL. Available from www.transport-links.org/transport_links/filearea/publications/OVERSEAS ROAD NOTE 03.PDF.

Nepal, Department of Roads (2008). Design Report Hilepani–Diktel Road (including link to Lamidanda) under Road Improvement Project (RIP).

Dhakal H. P., and Ghimire Chudamani (2011). Otta Seal Surfacing. Training Material for the officers of Democratic People's Republic of Korea. Organized by Transport Division, United Nations Economic and Scientific Commission for Asia and Pacific, Nepal Administrative Staff College, and Full Bright Consultancy, Kathmandu. (Unpublished).

Nepal Administrative Staff College (2011). Training report: trainingcum-observation study programme on stabilization of unpaved road for the officers of Democratic People's Republic of Korea. (Unpublished).

Shrestha, Bhagwan (2011). Bituminous Surfacing. Training Material for the officers of Democratic People's Republic of Korea. Organized by Transport Division, United Nations Economic and Scientific Commission for Asia and Pacific, Nepal Administrative Staff College, and Full Bright Consultancy, Kathmandu. (Unpublished).