PAVING OF CONCRETE ROOF DECKS

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ABSTRACT

There are a number of special considerations that must be taken into account when designing and installing concrete block paving (hereinafter referred to as CBP) on a concrete slab, especially an exposed roof deck.

The drainage of both surface water and water that penetrates through the paving into the bedding sand must be accommodated. To this end, the falls of the slab and outlet points must be considered at the design stage. In addition, a deck drain above the waterproofing membrane and beneath the bedding sand should be considered. The grading of the bedding sand and jointing sand as well as the sealing of the joints must be considered and are not necessarily the same as for normal CBP.

The thermal movement of the slab must be allowed for in the design and layout of the CBP and if a parapet wall is used as an edge restraint, it must be designed to withstand the horizontal forces induced by the slab movement which can be quite considerable.

The concrete slab is a flexible structure which will deflect and vibrate under traffic. The effect of this on the movement of the CBP and settlement of the jointing sand must be considered.

If speed humps are required to limit the traffic speed, then the geometry and construction of these humps must be taken into account. The approach ramps to roof decks are generally fairly steep and special precautions must be taken if these ramps are to be paved.

In this paper, all these special considerations will be discussed in detail with recommendations and examples of the use of CBP for roof decks in South Africa will be illustrated.

1. INTRODUCTION

CBP has become, in South Africa, the most common form of pavement construction for roof decks which are used for parking in commercial developments. A number of old roof decks (over fifteen years) which were surfaced with asphalt have needed to be replaced with CBP as the asphalt has deteriorated, causing damage to the waterproofing membrane and hence leaking has occurred into the building below, which is generally either offices or shops.

More recently, roof decks have been designed from the outset with CBP but some problems have occurred because certain critical special considerations have either not been considered at all or have not been designed and constructed adequately.

These critical special considerations are:

1. Drainage of water both surface and sub-surface.
2. Movement of the slab, both thermal and vibration movements.
3. Edge restraints.

A typical section through a roof deck is shown in Figure 1 and the use of the individual components will be discussed.

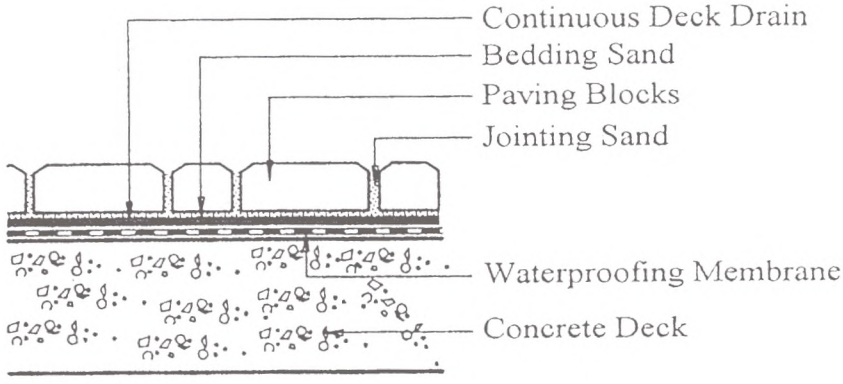


Figure 1 Typical Cross Section through Pavement

2. PAVING

The actual paving blocks do not need any special consideration as they are really only performing the function of a wearing surface and 50 mm thick pavers for pedestrian traffic or 60 mm thick pavers for vehicle traffic are more than adequate.

Eco-pavers can be considered if it is preferred that all the rainwater passes through the CBP and a drainage system is provided beneath the paving.

3. DRAINAGE

A sufficient number of drainage outlets of adequate size must be strategically positioned at the low points of the slab to ensure that the full volume of water can be drained. Often 100 mm diameter forbore outlets are used and these are too small to cope with the volume of water in a severe rainfall situation. In addition, during the dry season, these outlets become blocked with extraneous materials such as cigarette butts, plastic, paper and other waste materials.

Large rectangular drains (minimum 500 mm x 500 mm) are far more preferable and these must also be designed to catch the sub-surface water from the bedding sand or deck drain. Figure 2 shows a typical drain detail.

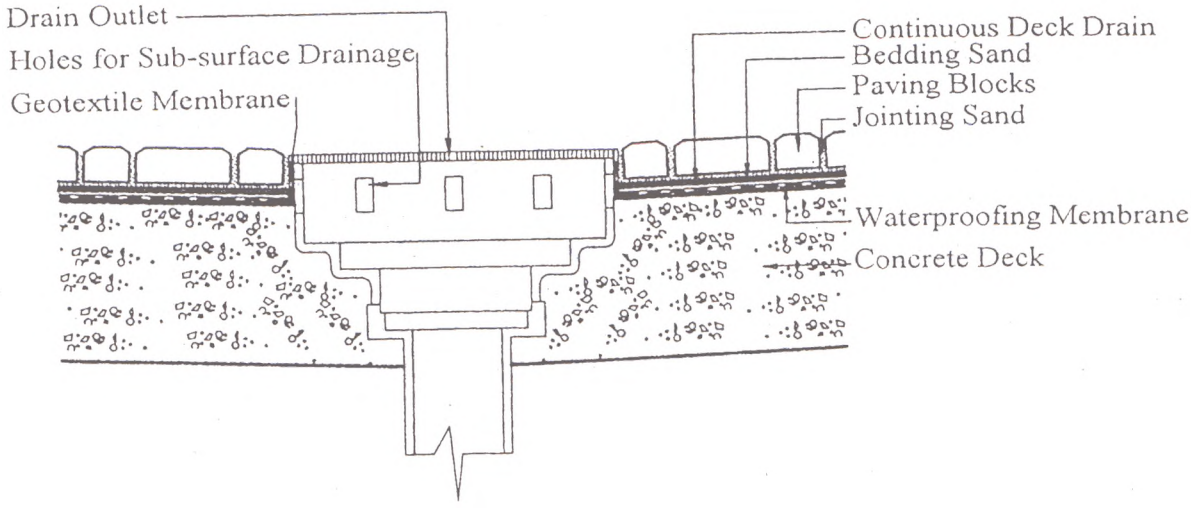


Figure 2 Detail at Drain Outlet

It is also essential that the CBP is laid approximately 5 mm above the level of the drain to ensure that the water flows into the drain and does not pond around the drain.

3.1 Surface Water

Roof decks are often designed and constructed without due consideration to the drainage of rainfall. The concrete deck is often cast flat and then falls are created with screeds but due to a number of constraints, insufficient falls can be achieved. These constraints include fixed levels at entrances and exits and weight restrictions in the design limiting the thickness of the screed.

It is essential that the minimum falls in the concrete slab be as specified in SABS 1200 MJ [1] which are 1% in the longitudinal direction and 2% in the transverse direction. This will prevent ponding, which is inconvenient to pedestrians and causes excessive amounts of water to penetrate through the CBP, and will ensure that the surface water and the water that penetrates through the CBP will flow into the drains.

3.2 Sub-surface Water

In a study by Shackel [2], it was shown that approximately 25% of rainfall may penetrate the joints in newly laid and unsealed CBP and even with sealing there will still be water penetration. It is therefore necessary to drain the water that penetrates through the CBP.

It is preferable that the volume of water penetrating through the CBP be kept to a minimum and therefore it is recommended that proprietary water-activated jointing sand be used and/or liquid sealants be applied to the joints. In both these cases, it is essential that the joints are completed filled and regular sampling should be carried out by lifting

pavers to ensure that the joints are completely filled. The loss of jointing sand due to trafficking is one of the major causes of movement of the CBP which leads to saturation of the bedding sand, pumping and ultimately failure of the CBP.
If the falls are adequate then the sub-surface water will flow in the bedding sand provided it has a suitable grading. It is essential that the grading of the bedding sand at least conforms to SABS 1200 MJ and is preferable if the fine material, i.e. < 0,075 mm, is eliminated completely.

For non-trafficked roof decks, single size pea gravel can be used as the bedding layer and the joints left open so that water may drain rapidly from the surface. Professor Alex Visser of Pretoria University is currently researching the possibliity of using a lightweight foamed concrete as the bedding layer for CBP on concrete roof decks.

If the falls are inadequate for suitable drainage of the bedding sand or there is concern that the bedding sand may become saturated, then a drainage system must be installed beneath the bedding sand.

One system that has been used is a herringbone drainage pattern using geotextile wick drains as the drainage material. However, these drains have tended to become blocked and local pumping of the bedding sand has occurred as described in the paper by Knoesen [3]. Also the bedding sand layer thickness will be reduced across the drain which can cause differential settlement of the CBP.

The preferred system is a continuous deck drainage layer beneath the bedding sand. This can be an open-graded granular base or there are a number of proprietary membranes available. The most common and suitable is a geocomposite drain consisting of a studded polystyrene core covered with a strong woven polypropylene filter fabric. This woven fabric filter allows water to pass into the drain core while restricting the passage of the bedding sand. There are different sizes of cores available to suit the predicted volume of water and the traffic loading.

4. MOVEMENT OF CONCRETE DECK

There will generally be fairly large movements in the concrete slab mainly due to the temperature variations, especially if there is not an insulation layer on top for the slab. This movement is accommodated by the introduction of control joints through the concrete slab at regular intervals.
There are many cases where the CBP is laid continuously across the control joint and this causes the joints between adjacent paving blocks to open up which result in the loss of jointing sand, excessive water ingress and movement of the CBP resulting in failure of the paving.

It is therefore essential that the control joint is continued through the CBP and an edge restraint must be introduced on either side of the joint. This can be simply achieved by casting an insitu concrete upstand on either side of the joint (see Figure 3) or bolting a steel angle to the slab on either side of the joint (see Figure 4). The gap must naturally be suitably sealed to prevent water ingress.

Alternatively, a proprietary expansion joint assembly as used on bridge decks can be fixed to the concrete slab.

It is preferable for the control joint to coincide with the high points of the slab to reduce the volume of water flowing across the joint.

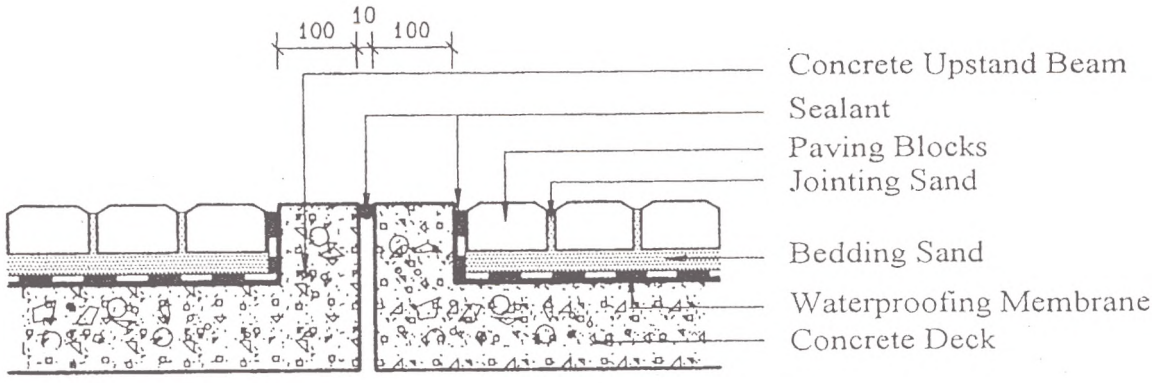


Figure 3 Detail of Control Joint with Concrete Upstand Beam

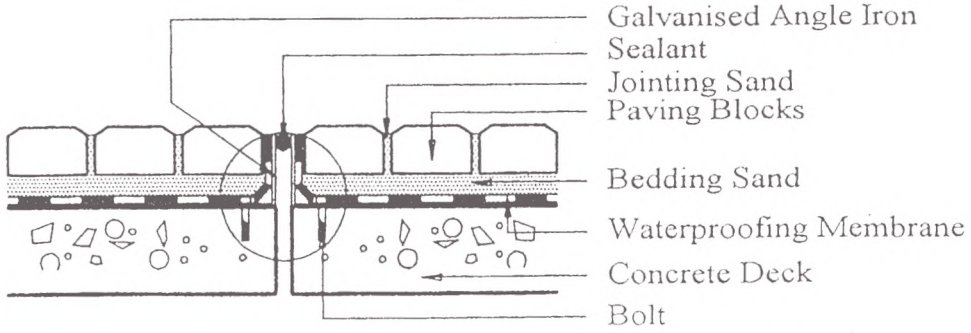


Figure 4 Detail of Control Joint with Angle Iron

There will also be a certain amount of deflection and vibration of the roof deck depending on spans, traffic intensity and method of construction. If it is a post-tensioned prestressed slab then the vibrations may be significant and cause loss of jointing sand. In this case, it would be necessary to inspect the CBP regularly and re-fill the joints until "lock-up" has occurred.

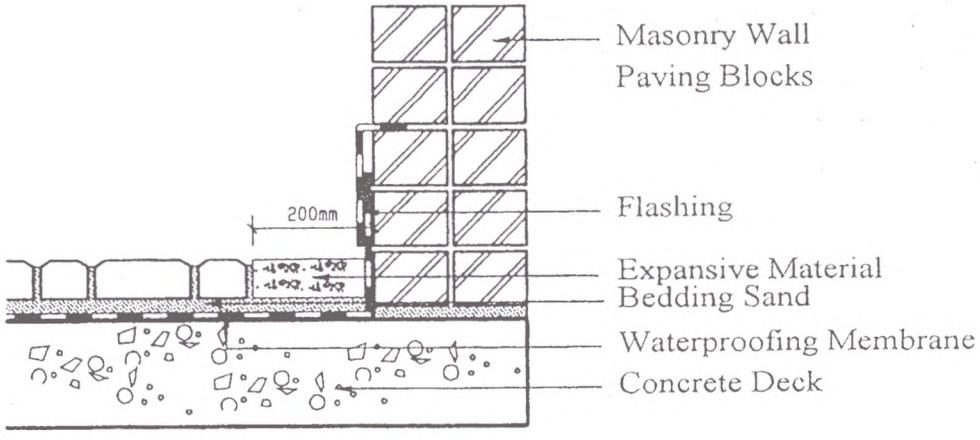
5. EDGE RESTRAINTS

Generally buildings, protrusions and perimeter parapet walls are used as the edge restraints for CBP on roof decks. If there are segregated vehicle traffic lanes and

pedestrian walkways, then these will be normally demarcated with precast concrete kerbs in the standard manner.

If a masonry parapet wall is built and is to be used as the edge restraint, then it must be designed to withstand the horizontal forces created by the concrete slab movement. There are many cases of masonry walls cracking due to these forces and in extreme cases, parapet walls have been pushed off the edge of the slab.

It is recommended that an expansive material is placed against the wall and it is essential that the CBP slopes away from these walls to prevent ponding of water against the wall and also that the joint is sealed to prevent the high volume of water that can run down a wall from entering into the bedding sand layer. See typical details in Figures 5 and 6.



Figures 5 Slab/Wall Junction

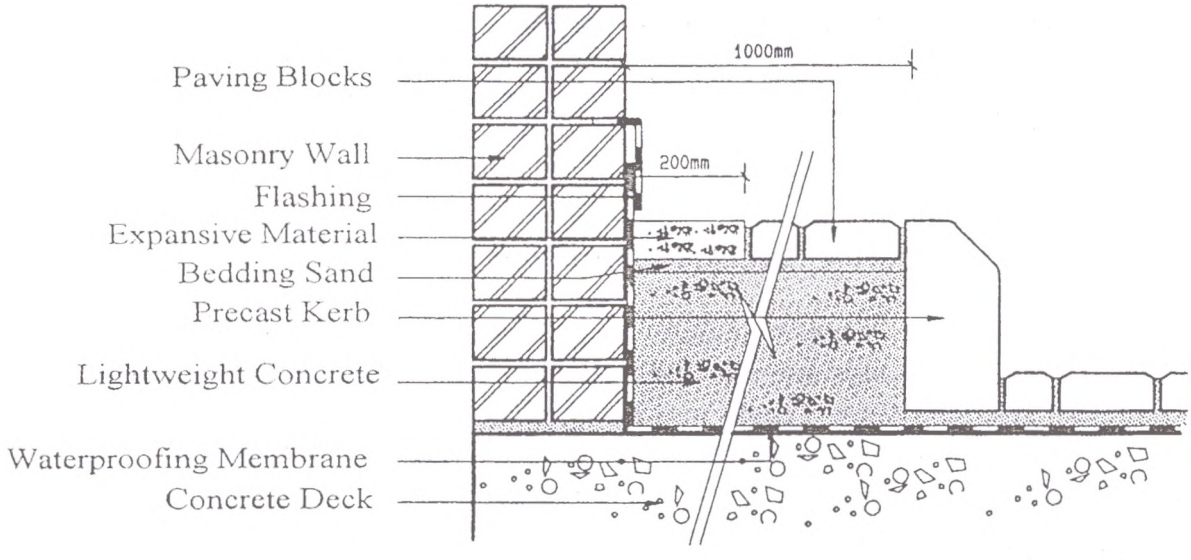


Figure 6 Slab/Wall Junction with Walkway

6. OTHER CONSIDERATIONS

Two other aspects which are not only related to roof decks but need careful consideration are speed humps and access ramps which are generally fairly steep.

The geometry of the speed hump must be such that there is not a high impact force causing movement of the CBP and it is strongly recommended that speed humps do not coincide with control joints.

The normal precaution of CBP on steep slopes should be taken into account for the access ramps, especially relating to drainage. If insitu concrete beams are used as anchor blocks, then weepholes must be cast in the beam to allow the passing through of water and prevent drainage.

If an insulation layer is required to be placed on top of the slab, rather than underneath the slab, then the material must be able to withstand the static and dynamic loads of the traffic.

7. RECOMMENDATIONS

(1) The drainage systems for both surface and sub-surface water are of paramount importance for the CBP to perform adequately.

(2) The volume of water penetrating through the CBP should be minimised by using proprietary jointing sands and surface sealants.

(3) The movement of the concrete deck must be catered for in the CBP.

(4) All edge restraints must be capable of withstanding the loadings, both vertical and horizontal.

8. CONCLUSION

Concrete Block Paving is a very suitable pavement material for the paving of roof decks from both a performance and aesthetic point of view provided it is properly designed, detailed and constructed.

As with all CBP, regular inspection of the paving, especially during its early life, will highlight any minor problems before they develop into major problems and the necessary remedial measures can generally be taken at a relatively small cost.

REFERENCES

1. South African Bureau of Standards, Standardized Specification for Civil Engineering Construction, MJ : Segmented Paving, 1984.

2. Shackel, B. (1998) An Experimental Study of Methods for Sealing concrete Block Pavements, Proceedings of the 3rd International Workshop on Concrete Block Paving, pp. 38-1 to 38-11.

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