SfB : BC_2
UDC : 69.0592

BUILDING RESEARCH NOTE

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APRON - A REMEDIAL MEASURE FOR CRACKED BUILDINGS IN EXPANSIVE SOILS

Introduction

Cracking of building in expansive soil areas has always been a matter of concern to the builders. Commonly adopted strip footings are subjected to differential movements which damage the superstructure. The phenomenon of differential movement due to unequal heave or shrinkage was recognised by the engineers in the past, but it was towards the middle of this century that expansive soils were studied in detail and safe foundation systems evolved. However, in expansive soil areas, the problem of cracking still persists in buildings which are inadvertantly founded on shallow footings.

Moisture Variation and its Effect

Expansive soils show high volume changes when subjected to moisture variation. This is generally due to montmorillonite which is the prominent clay mineral in these soils. These soils are not necessarily black in colour and soils of other colours also may exhibit swelling and shrinking phenomenon. They become hard, when dry and soft, when wet. During drying, shrinkage occurs in both the vertical and horizontal directions. When monsoon sets in, soil absorbs moisture and starts swelling which fills up the cracks in soil. Finally, the ground heaves up to the maximum towards the end of monsoon. The magnitude of swelling pressure is high enough to move the shallow footings of light structures. As the ground movements due to swelling and shrinking do not occur uniformly, differential movements set in causing the cracks in bu ildings.

Besides seasonal moisture changes, movements occur because of the nature of area, covered or otherwise. The moisture content beneath the building is prevented from evaporation particularly at the centre and it increases till an equilibrium is reached and the central portion heaves up. It may be due to the fact that prior to the area being covered by the building the physical forces of suction, capillarity, evaporation and transpiration from vegetation are in equilibrium. A new equilibrium is struck under covered areas in due course of time.

Nature of Cracking

When a covered area is subjected to hogging, the traditional buildings of unreinforced brick masonry crack due to tensile strains in bending showing a crack pattern wider towards top. It is well recognised that hogging is more critical for cracking than sagging. Shear deformation gives rise to diagonal cracks. In actual cases the cracks are not ideally vertical and/or diagonal as these are influenced by other environmental factors and the type of superstructure. Exposure towards south and west in the direction of maximum sun and presence of trees and vegetation may further aggravate moisture changes and consequent damage. Similarly man made wetting or drying may also create problems. Cracks follow the line of least resistance and, therefore, openings, in building, weaknesses in material and construction defects suffer most and tend to localise and modify the pattern of cracks. Presence of roof slab (s) tend to control the widening of cracks towards top. In the initial stages, cracks are of a minor nature and as the summer advances, they tend to open up. In monsoons, they may close partially. But with repeated cycles, the problem aggravates and in severe cases there may be through cracks, loosening of masonry, tilting of walls and eventual structural collapse. Remedial measures are more effective when there is little structural damage.

Remedial Measures

Obviously the solution lies in protecting the foundations against differential movement of the ground. This can be achieved either by taking down the foundations to a depth where no ground movement occurs or by maintaining the soil moisture constant so that changes due to swelling and shrinking do not occur. In Indian expansive soils, the stable strata at which no ground movement due to seasonal moisture changes occur, is at a depth of about 3.5 m. Therefore, one of the solutions is to extend the shallow footings upto 3.5 m. But it involves elaborate underpinning operations. It is complicated, time consuming and too costly for common buildings.

To keep the moisture content constant by keeping the soil in dry state or saturated state is not practical due to environmental and practical reasons.

The problem can, therefore, be best tackled by minimising the moisture gradient between the edges and the centre of the covered area. This can be achieved by extending the covered area around the building by providing an apron. An apron at the top of ground is not advisible because it is liable to damage by external forces or differential movement of the ground over which it rests. A flexible waterproof apron of about 2 m width provided at a depth of about 50 cm is more appropriate.

The best time for providing an apron is at the end of monsoons. The soil should be neither too dry nor too wet. It should be dug out around the building upto a depth of about 50 cm. The surface should then be dressed and given an outward slope of 1 in 30. Over this sloping surface, a flexible apron which may accommodate ground movements without rupture is laid. It can be a 100 mm lime concrete layer over which a tarfelt preferably fibre based, is laid. The lime concrete mix can be 16:32:100 with lime surkhi or cinder : brick or stone aggregate. In place of tarfelt a polythene sheet 250 micron thick or more can be used. Care should be taken that no mechanical damage is caused to the waterproof membrane. The apron should go about 75 mm into the foundation wall by housing in a chase so that no room is left for evaporation or saturation from the joint. The width of the apron may be kept 2 meters. A typical section of the apron is shown in Figure 1.

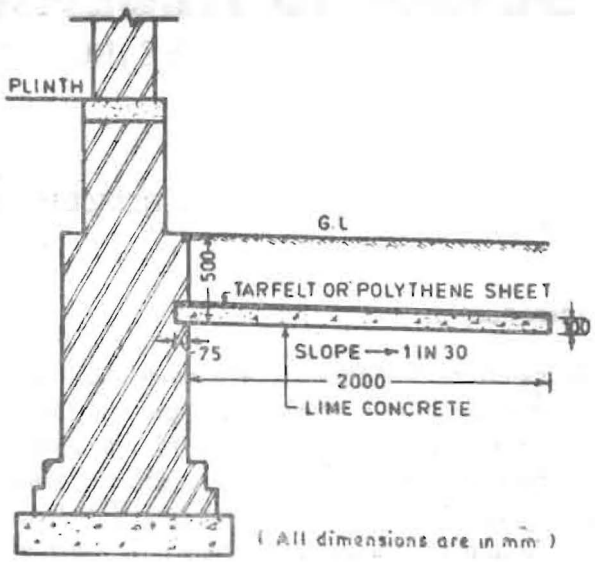

FIG. 1 DETAILS OF APRON

After laying the apron, the soil should be backfilled and properly dressed to give an outward slope of 1 in 30. It will protect the apron from damage.

The cracks should be repaired by raking, cleaning, removing any loose plaster and filling them with mortar. In case cracks are through and through, brick joints should also be cleaned and filled with mortar and repaired on either side. The filling should preferably be done by a cement, lime and sand mortar. A suitable mix of 1 : 2 : 9 is suggested.

As a further precaution against severe moisture changes, trees and shurbs which may suck in considerable moisture should be planted at a sufficient distance, away from the building. Similarly, ponding of water and excavation near the building should be avoided. It has been observed that the underground flexible aprons around buildings arrest further cracking. After two cycles of seasons, the cracks tend to become stable and no further damage is observed in normal summer and rainy seasons.

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Published by :
Central Building Research Institute
Roorkee (U.P.) India
First Published as B.D. 141 in January, 1981
Reprinted Feb. 1987.

Printed at :
Jain Printing Press, Roorkee
Copies, 3000