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P. K. Jain
*MANIT, Bhopal, India*

Rakesh Kumar
*MANIT, Bhopal, India*

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# REPAIR OF SUNKEN FLOOR BY INTEGRATED APPROACH: A CASE STUDY

**P. K. Jain, Professor,**
MANIT, Bhopal, M.P. 462051, India,

**Rakesh Kumar, Assistant Professor**
MANIT, Bhopal, M.P. 462051, India

## ABSTRACT

The floors and non load bearing walls of a house, having expansive black cotton soil underneath, have been repaired by two methods. A part of the damaged house floors and walls were repaired by the conventional method i.e. removing the expansive soil completely and replacing with non expansive granular material. The remaining part was repaired by integrated approach as described later by Jain and Mewade (2010). The Jain and Mewade (2010) approach consists of removing the expansive soil underneath the damaged floor by about 0.5m, making 50mm diameter, 1m deep holes at 0.75m centre to centre and filling lime slurry in the holes. The broken floor debris and non expansive soil was then filled up to the floor base level and the cement concrete floor was reconstructed. The floor constructed by removal of expansive soil by 1.5m depth in the first method and partial removal and making lime piles in the second method are performing well with no sign of settlement or unevenness any where. The paper presents the success story of one such house repaired by these methods in the year 2008. The second method requires only partial removal and replacement of problematic soil beneath the floor and therefore is fast and economical in comparison to conventional method.

## INTRODUCTION

Madhya Pradesh is one of the states in India having large area covered with expansive black cotton soil. Generally the topsoil is black in color followed by either yellow soil or the weathered (fully or partially) basalt or both. The black soil is good for growing cotton and hence is popularly known as black cotton soil. Both the black cotton soil and yellow soil are residual soil derived mainly from in-situ weathering of the basalt under semi arid climate.

The depth of black cotton soil is generally 3-4m in most of the places but it may be as low as 0.5m to as much as 10m. The Civil Engineering construction on black cotton soil faces severe problems due to swelling and shrinkage nature of the soil which is attributed due to seasonal moisture variation. A huge loss of capital both in public and private sector is taking place due to failure of structures founded on such soils. The failure cases include roads, boundary walls, railway embankments, houses etc. Lack of knowledge about the nature of soil and poor engineering practice are the main reasons for such failures and loss.

Bhopal, the capital city of Madhya Pradesh, is also having topsoil as black cotton soil at most of the places. The MANIT Campus in Bhopal has black cotton soil layer; the depth of which in the campus varies from 1 to 4 meters and is followed by yellow soil and/or highly weathered basalt. A number of houses constructed around the year 1975, in the campus of MANIT, Bhopal are facing the problem of sunken floor. The soil under the floor is black cotton soil. Not only the floors but the partition walls as well, in ground floor houses have diagonal cracks at different levels. The light weight non load bearing walls at many places have left floors and gap between wall and floor can easily be seen. Earlier attempts to repair the cracked walls or patch repair of the floors did not prove effective as within after few months of repair the similar problem reoccur either at the same or the other location. Hence, in order to have the permanent solution to the above problem, in the year 2008, repair work of a few residential single story houses has been under taken.

The paper discusses the success story of one such house that has been repaired by two methods, one the conventional approach comprising removal of problematic soil and replacing by good non swelling soil and the other the integrated approach as described by Jain and Mewade (2010).

## PROBLEMS OF HOUSES IN EXPANSIVE SOIL

A structure resting on expansive soil may suffer from damage that may be apparent usually several years after the construction. During the wet season, the soil below exerts

swelling pressure both upward and laterally. As a result, the floor slab is lifted up, typically in an irregular dome shaped or corners- down pattern, leading to the cracking of floor. The footing walls are pushed outward and leading to cracking of the end walls of the structure. Since there is restriction of movement at the junction between the walls and the floor as well as between the walls and the roof slab, structural distress is apparent at these locations which are exaggerated by shrinkage of soil in following summer months leading to loss of support. Cracking is also normally evident at the corners of the window and door openings. These usually assume the form of diagonal cracks – a consequence of differential settlement in the walls (Ranjan and Rao, 2002). These problems are very common to all structures which are constructed on black cotton soil. In initial stage, the cracks are minor, but as time passes the cracks increase, finally the floor get sink or settled. In many situations the problem is only with the floors and partition walls. The main walls and columns are laid deep and the superimposed load is enough to counteract the upward pressure exerted by the swelling soil.

## REPAIR OF SUNKEN FLOOR: GENERAL PRACTICE

The deformed floors are traditionally been repaired using methods seeking to overcome the expansive soils forces through i) Soil removal and replacement by good soil, ii) Soil stabilization, iii) R.C.C. flooring.

Expansive soils have relatively shallow occurrences to within 2.0 to 4.0 meters from the natural ground surface. However, in some cases it may be more than 4m deep. At such places it is problematic and costly to remove the existing soil to greater depth and to replace it with other good soil. Stabilization or modification of expansive soils by chemical admixtures is a common method for reducing the swell-shrink tendency of expansive soils. Among various chemical stabilization methods, lime stabilization is most widely adopted method (Wagh, 1999, Venkataswamy 2000). Generally, the quantity of lime required varies from 4 -10% by weight of the soil (Eades et al. 1963). The deep stabilization of soils by lime columns, lime piles and lime slurry injection techniques have been successful for stabilizing soft soils deposits (Rao, 1992). Soil stabilization by lime is more effective in controlling volume changes, increases the overall strength of the stabilized soils and this method is suitable for shallow depth. Reinforced cement concrete floors are costly and at times the swelling pressure of soil may disrupt them also. Hence it is desirable to attempt stabilization (reduction in swell-shrink behavior) and strengthening of soil with minimum removal and replacement of the existing expansive soil. Jain and Mewade (2010) have discussed the method of repairing sunken floor without replacing large volume of existing expansive soil in the minimum time and with economy. The method is named as integrated approach of repairing sunken floor laid on expansive soil.

### Integrated Approach

The integrated approach aims at

- Minimizing moisture variation in the soil and
- Providing unyielding and uniformly strong support beneath the floor.

**Minimizing the Moisture Variation:** This may be achieved by provision of plinth protection slab at the outer periphery of the building of sufficient width (1.5 m or more) if possible and keeping away the deep rooted plants from the periphery of the building.

**Providing Unyielding Support beneath the Slab:** This could be achieved by removal of 0.3m to 0.5m of expansive soil immediately below the damaged floor and placing non expansive soil in place, lime treatment of existing expansive soil and construction of cast in situ short concrete piles of 150mm to 200mm uniform diameter and length of 1.5 m – 2.0 m @ 1.0 m to 1.50 m c/c below the removed expansive soil level.

## THE CASE STUDY

In the year 2008, repair work of a few residential single story houses has been under taken in MANIT campus, Bhopal. The case of one such house repairing is discussed below:

### Condition of House Prior to Repair

There are three bedrooms, drawing room and dining hall, office room, kitchen, store and two sets of lat-bath and a courtyard. The plan of the house is shown in Fig.1.

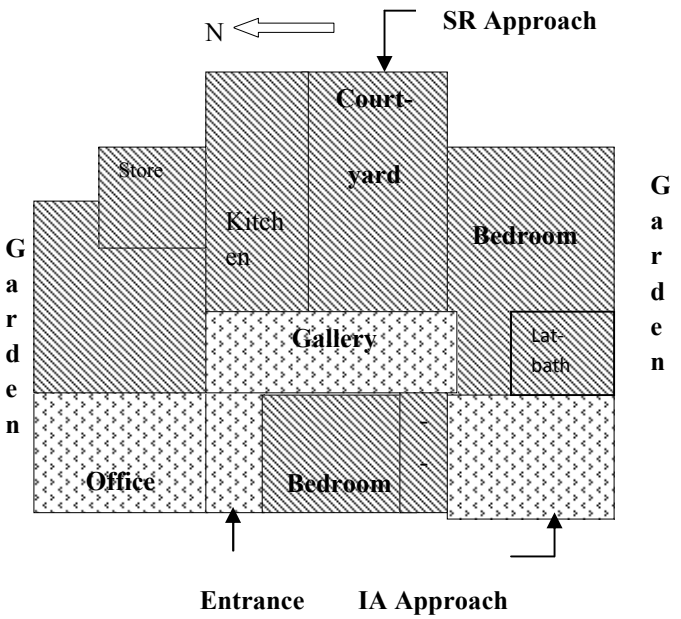


*Fig. 1. Plan of house showing repair of floors by two approaches*

The house is having plinth protection about 75 cm wide in outer side. The adjacent house is located on east side and is the mirror image of the house described herein. Towards the north and south of the house, open land is used for gardening. The west side of the house has flag stone flooring for parking of vehicles. Besides one mango tree in the courtyard the house is surrounded by many trees and shrub which includes Azadirachta indica, tamarind, sapodilla, guava and eucalyptus in the garden portion.

The house is having load bearing walls of stone masonry placed at about 1.5 m below the natural ground level. The floors of the house had been irregularly sunk and cracked nearly in all rooms and courtyard. On walking in the house, one could hear typical hollow sound at many places, perhaps due to the formation of cavity under the flooring. The floor was made up of cement concrete and was about 100 mm. As stated earlier the partition walls had also got severe diagonal cracks at many places and at some places the wall has gap with floor and / or to the roof slab. Figure 2 and 3 depicts the defects as stated here.

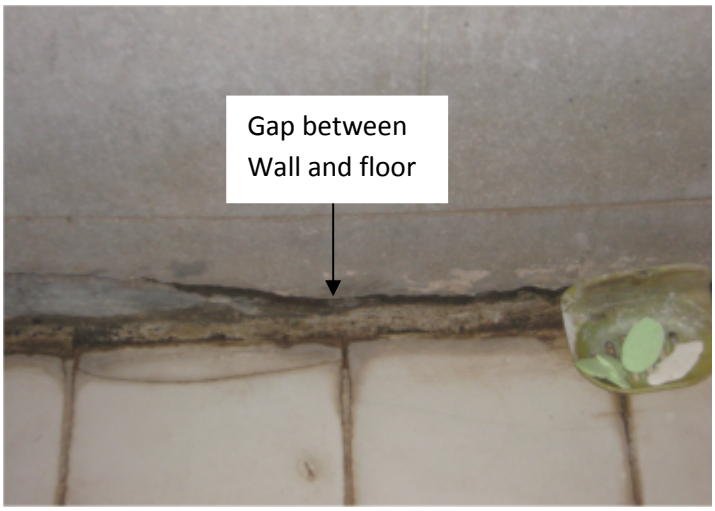


*Fig. 2. Gap between sunken floor and non load bearing wall*

The plinth protection made up of cement concrete around the house also got damaged and was having undulation throughout its length. Similar was the situation in the courtyard portion. Further, the drainage pipelines passing through the courtyard used to get chocked many times during a year and need to be cleaned through the drainage chamber openings .It was found that chocking was because of tree roots.

## Soil Properties and Repair of House

The soil under the floor is black cotton soil up to 1.5m depth and is followed by highly weathered vesicular basalt.
The black cotton soil is tested in the laboratory and is identified as CH soil i.e. clay of high plasticity and compressibility as per IS 1498-1970. It has minus 75 micron fraction, liquid limit, plasticity index and differential free swell values as 94%, 56, 35 and 52% respectively. The swelling pressure of the soil was determined as 60kN/$m^2$per IS. The weathered basalt is coarse grained and found in dense state.

*Fig.3. Damaged wall of bedroom*

As mentioned earlier that repairing of sunken floor and cracked partition walls of the house has been carried by two approaches. These are discussed as soil replacement approach (SR approach) and the integrated approach (IA approach). The repairing work was carried in phases, a few rooms taken at a time, as the residents continued to stay in the other portion of the house.

**Soil Replacement (SR) Approach:** The removal of soil was planned in SR portion as shown in Fig.1. The damaged floors were removed and soil underneath the floor was taken out up to 1.5m depth. While removing the soil from the rooms the roots of the trees were found at many places. It may also be one of the reasons for moisture fluctuation under the floor resulting in uneven settlement. Locally available non expansive coarse grained red soil and the crusher dust was filled in small thickness and compacted to prepare the base for the floor. After the desired level of the floor base reached cement concrete of grade M15 was laid in 100 mm thickness and mosaic tiles were then fixed. RCC beams of width 20cm depth 30 cm were placed under the partition walls. The beams were resting on the main stable load bearing masonry wall.

**Integrated (IA) Approach** For repairing the IA portion (Fig. 1) following methodology was adopted:-
The damaged floor was removed and the soil for about 500mm was also removed. Using hand auger and a vibratory needle rod, the holes of diameter 50mm in the black cotton soil was then made at every 750mm centre to centre. These holes were filled with stone chips size less than 8mm for about 300mm and followed by filling of Lime slurry up to the top soil level. Commercially available lime powder was used for this purpose .The depth of the lime pile was about 900mm. After all holes were filled in this way, the top of the soil was saturated with water. Stone dust / broken debris of the

damaged floor was then filled and compacted properly over the treated soil up to the desired level for making the floor. The cement concrete flooring of 100 mm thick and the mosaic tiles as laid for SR portion were then constructed.

The house was repaired in 2008 and has seen typical Indian weather cycles consisting of rains for three months (July to September) proceeded by intense summer season (April to June, maximum temperature 45°C). As such in no part of the house, any settlement is noted. The time required for repairing by the integrated approach is less than one forth the time taken by conventional method.

## CONCLUSIONS

The case of repairing the sunken floor of a house having black cotton soil underneath by integrated approach suggested in the paper is speedy, less cumbersome and economic with minimum disturbance for the residents of the house. And therefore, may be adopted as a permanent solution for sunken floor in the black cotton soil.

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