Geotechnical Evaluation of Subsidence Cracks at Priyanagar Under Chakdah Block, Nadia District, West Bengal – a Case Study

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Abstract

A 60m long and 2-4m wide ground crack developed on 26th September 2007 at Priyanagar under Chakdah Block near Kalyani town of Nadia District. Besides badly damaging an old pucca house, this subsidence crack endangered the adjacent house and other structures.A detailed study of the ground crack was carried out to evaluate the causes and to assess the gravity of the incidence.

Quaternary sediments, deposited by the west-flowing Bhagirathi river occupy the area. The two major Quaternary formations occupying the area are (i) Late Holocene Hoogly formation consisting of fine sand, silt & clay and (ii) Mid- to Late Holocene Katwa /Arambagh formation consisting of alternate layers of sand, silt & dark gray clay. The sediments of both these formations are unoxidised and unconsolidated in nature.

Field studies revealed a 30-75 cm deep and N65°-80° E-S65°-80°W trending crack confined in between two man made ponds with a level difference of 10 to 12m and a separation of 85-90m, with the gradient being westwards. The damaged house and the prominent subsidence zone occur along the crack and lie in between these two ponds. Three segments are discernible in the crack from NE to SW, viz i) crack traversing the ground, ii) cracks traversing the house and iii) cracsk traversing the subsidence zone.

Subsidence of ground and its effect on surface as ground cracks is generally due to four causative factors, which may be responsible either singularly or severally, viz i) Seismic activity, ii) Overdraw of groundwater, iii) Mining activity and iv) Presence of buried channel

The paper discusses, in detail, about the nature and impact of each cause, before pointing at the presence of a buried channel as the most likely causative factor responsible for the occurrence of ground cracks at Priyanagar.

Introduction

Subsidence ground crack, measuring 60m in length and 2-2.4m width developed on 26th September 2007 morning at a place called Priyanagar under Chakdah Block near Kalyani town of Nadia District, West Bengal. Besides badly damaging an old pucca house, this ground subsidence has endangered the adjacent house and other structures, thus creating panic among the locals in general and the occupants of the pucca house in particular. A detailed study of the earth crack was undertaken to find out the causes and assess the gravity of the incidence, at the request of District Magistrate, Nadia, to work out appropriate remedial measures.

The residents of the badly damaged house first noticed the cracks, both on the ground and in the house, on 26th September early morning, after a heavy downpour in the locality. No casualty however was reported. Another house in front of the damaged house and located 10-12m away from the crack alignment remained unaffected and with no sign of distress visible.

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Site Geology

The area is covered with Quaternary sediments deposited by the river Bhagirathi which flows from east to west. The present course of the Bhagirathi river is about 1.5 to 2 km west of the area of study. The two major Quaternary formations of the area are i) Hoogly formation consisting of fine sand, silt and clay of Late Holocene to Recent age and ii) Katwa/Arambagh formation consisting of alternate layers of sand, silt & dark gray clay representing natural levee and flood basin zone of Mid- to Late Holocene age. Sediments of both these formations are unconsolidated in nature. Near the investigated area, a number of detached crescent shaped water bodies, having convexity towards east and aligned almost parallel to the present river course are noticed which indicates that the river course has shifted towards west. These detached linear water bodies, if joined will mark the palaeo course of Bhagirathi river (Fig. 1). No hard rocks are exposed in and around the locality and the buildings in the area are founded over soil.

Nature of cracks

The 30-75 cm deep crack trending N65^0-80^0 E-S65^0-80^{0}W is confined between two man made ponds with a level difference of approximately 10 to 12m and a separation of 85-90m, with gradient towards west .The pond in the northeast is a smaller one formed at a higher elevation of 31m, while the pond on the southwest is relatively bigger and is at a lower elevation of 17m.The damaged house and the prominent subsidence zone lie in between these two ponds and fall along the crack alignment. A schematic sketch of the cracks is shown in Fig. 1. The crack can be sub divided into three segments from NE to SW; viz, i) ground crack to the NE of the damaged house, ii) cracks in the house and iii) the subsidence zone to the southwest of the damaged house.

i. **Ground cracks to the NE of the damaged house:** A visible and prominent crack starts from the western flank of the small pond and extends continuously for a length of 17m up to

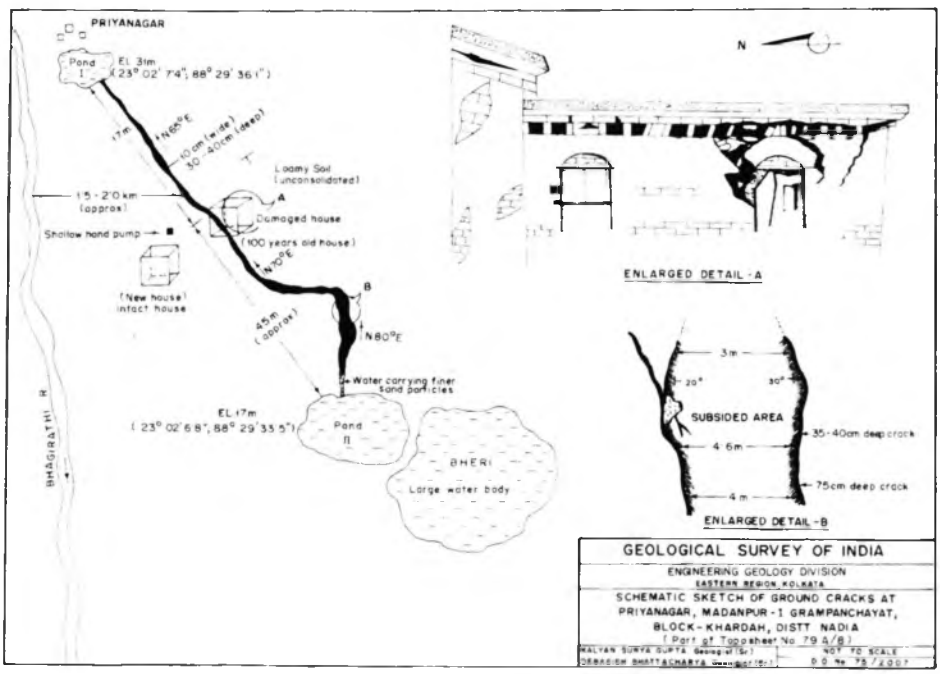

Fig. 1

the base of the damaged house. The crack in this stretch is 10cm wide and 30-40cm deep (Photo-1). The ground slope is towards the damaged house. The subsurface soil revealed by the crack is loose silty clay while on the surface it is clayey in nature and partly consolidated.

Photo 1

ii. **Cracks in the damaged house:** The 100years old house has been badly damaged with cracks all over the house, both inside as well as outside. The distress observed on the cemented floor, wall and ceiling reflects the gravity of subsidence. The tilting of the window and the base of the house is very prominent

Photo 2

(Photo-2). The bricks on the wall and over the window arch are dislodged and some of the bricks have fallen down (Photo-3). The ground crack passes below the house and the trend is N70°E-S70°W. Both the rooms of the damaged house are badly affected. The cracks are

Photo 3

irregular but continuous in nature. Another house, relatively new, to the northwest of the damaged one but away from the crack alignment has not been affected at all. It is reported that the hand pump in the north of this house has intercepted ground water at a shallow depth of 3.0 m with sand layers occurring at 3 to 4m below ground level.

iii. **Subsidence zone:** The ground crack extends further west beyond the damaged house up to the bigger pond. The ground in between the house and the pond has subsided up to a depth ranging from 35 to 75cm. The width of the affected area is 4.6m(max.). The tilting of a mango tree falling within this zone is very prominent. The cracks bounding the subsidence zone trend N80°E- S80°W and the approximate extent of this crack is 45m (Photo-4) . The width and depth of the crack

Photo 4

decreases towards the bigger pond. It gradually dies out and reappears at the eastern boundary of pond-II. The seepage of water, along the crack, from the smaller pond to the bigger one is not evident on surface but a discernible flow of water with carriage of finer sand particles is observed at the terminal point of the crack near the big pond (Photo-5). It was informed by the locals that the level of water in the smaller pond, which is at a higher elevation, was decreasing gradually, though the same could not be confirmed due to monsoon. The ground

Photo 5.

cracks in the subsidence zone are up to 75 cm deep and generally linear in nature though circular cracks are also noticed. The soil collected from the fissures indicates a silty-sandy-clay composition.

Discussions

Ground subsidence and consequent development of surface cracks generally take place due to the following four causes either independently or as a combined effect. The same are evaluated vis-à-vis the present case.

i) Seismic activity

ii) Overdraw of groundwater.

iii) Mining activity

iv) Presence of buried channel and particle carriage

i) **Seismic activity:** The preliminary data and information collected during the site visit do not indicate any earthquake related hazard. Villagers felt no tremor during the period; neither IMD recorded any event from the area. Past records also do not support the possibility of an earthquake. The amount of seismic shaking required to create such cracks on the wall and on the ground surface cannot go unnoticed by the people residing in the area; hence seismic activity as a causative factor is ruled.

ii) **Overdraw of groundwater:** It is learnt, from local residents and also from the water level observed in the nearby tube well, that the groundwater table in the area is very shallow (about 10 ft deep). The Bhagirathi river is about 1.5 to 2 km away from the affected area. The pond near the affected area has intersected groundwater table. At Priyanagar ground water is not being excessively drawn, moreover the area was already surcharged with water during monsoon raising the ground water level. Therefore the case of subsidence due to the possible cause of excessive pumping of ground water is also ruled out.

iii) **Mining activity**: Ground subsidence due to unscientific mining activities is common phenomena, particularly in coal belt areas. There is however no reported occurrence of any mineral or coal in the area investigated and as such, the question of mining activity related subsidence does not arise.

iv) **Presence of buried channel:** The presence of a buried palaeo channel in the area is well reflected in the geological map of the area. A number of detached water bodies having convexity towards east and aligned almost parallel to the present river course, near to the present location, indicate that the river course has shifted towards west and these individual linear water bodies, if joined together will indicate the palaeo course of the Bhagirathi river. The width of the subsidence zone probably represents the

width of the buried channel and its linear extension towards southwest may be the probable flow direction of the channel. This buried channel may have facilitated an easy passage of water from higher level pond to the lower level pond with enough head to cause removal of the loosely consolidated material. This may have created voids in the sub-surface causing the ground at Priyanagar, in between the two ponds, to subside.

The removal of fine sand and silt material by the underground water along a channel defined by the ground crack was noticed during the study. Hence, creation of extensive subsurface voids due to particle carriage by ground water is considered to be the most likely causative factor for the sagging of ground and development of ground cracks at Priyanagar.

Summary and Conclusions

The discussion afore presented is mainly based on field observations, feed back from locals and consultation of available maps of the area. The different causes of land subsidence and its signatures on the ground in the form of cracks have been geotechnically evaluated to arrive at a logical conclusion with regards to the causative factor.

Limited dimension of the cracks, their localized occurrence and damage confined tone house do not favour any seismic activity to be the causative factor. The availability of ground water at very shallow depth and occurrence of the event during monsoon, when the rate of recharge is at least equal, if not more, than the rate of drawal of ground water does not favour subsidence due to excessive drawal of ground water either. And since there is no mining activity in the present area, subsidence due to this factor is also ruled out.

The presence of a possible buried channel in the area is well reflected in the geological map of the area. A meandering course of the Bhagirathi and its westward shifting is an established fact. The removal of finer sand and silt material by the underground water along a possible buried channel has been noticed in the field. This buried channel seems to indicate the palaeo-course of Bhagirathi river. The width of the subsidence zone represent the width of the buried channel and its linear extension may be the probable flow direction of the channel. Sagging of ground and development of cracks due to the voids created underground - when the material (sand in this case) supporting the ground from below is removed by ground water is commonplace. Hence it is concluded that removal of subsurface sandy material by the ground water under head from high level pond to the lower level pond along the buried channel may have created voids in the subsurface resulting in subsidence and ground cracks as a consequence.

Further, although resently no crack of any magnitude is seen in the house adjacent to the damaged one, presence of any weak zone below or adjacent to this house needs to be ruled out. Monitoring of the cracks and study of subsurface soil samples for their physico-mechanical properties in the affected area and near the big pond, where sand is draining out, is necessary for a more comprehensive geotechnical evaluation of the ground at Priyanagar.

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