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Risk Assessment of the Structures Built on Reclaimed Lands in Jabalpur M.P.

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ABSTRACT:
This paper describes the risk assessment of the civil engineering structures built on reclaimed lands. The problems that are likely to arise wherever major civil engineering structures are being planned on lands which have been reclaimed from perennially water logged areas or from the areas reclaimed by back filling the old surface water bodies and old garbage dumps. This practice is being followed in Jabalpur city which once supported 52 major and 84 small water bodies (Talabs) out of which nearly 100 have lost their existence and residential colonies now occupy lands reclaimed from them. As in Jabalpur so also in others towns this activity is going on without considering the negative effects of using reclaimed land for major constructions.
Keywords: Municipal Solid Waste (MSW), SONATA, ENE- WSW, NNF, NSF

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I. INTRODUCTION

Land reclamation usually known as land fill process of creating new land from ocean, river beds or lake beds. The land reclaimed is known as reclamation ground or land fills. Industrial and commercial developments of urban area require a large usable land which could be possible by reclamation. So many advanced countries e.g. Japan, Singapore, USA, Hong Kong, Netherlands, Dubai (UAE) etc are obtaining lands by reclaiming sea shore. Palm Island at Dubai, The entire East Coast Park at Singapore, Peninsula long beach USA, Hong Kong International airport are the best examples of advanced constructions built on reclaimed lands.

These countries are so advanced in technology and well equipped with the modern techniques for land reclamation, so that these advanced countries apply the process of reclamation and use theirs reclaimed lands for modern constructions. But in country like India where advanced techniques of land reclamation are not of such standards, so we cannot ignore the disadvantages of wrongly land fill. Constructions on improper land fill always invites disaster. This paper present a study of losses of structures built on lands obtained after reclamation or building structures built on edges of the lakes of the town encroached by the local residents.

II. ABOUT THE STUDY AREA

Jabalpur is a city situated in the central Indian state of Madhya Pradesh. The city's name is derived from the legendary sage Jaabaali, who is mentioned in the Ramayana, and may refer to Jaabaali's tapasya-bhoomi (place of penance). According to Bheegnari folklore, a small cave on the bank of the Narmada River was Jaabaali's ashram. Variations of the name include Jabalipuram, Jubbulgarh, Jabalipattanam and under British rule the city was known as Jubbulpore. Jabalpur is located at 23°10′N 79°57′E / 23°17′N 79°95′E. The central point of India is located at village Karondi in Jabalpur district. It has an average elevation of 411 meter. Historically, Jabalpur is a centre of the Kalachuri and Gond dynasties, the city developed a syncretic culture influenced by intermittent Mughal and Maratha rule. During the early nineteenth century, it was annexed by British India as Jubbulpore and incorporated as a cantonment town. Bheraghat is a unique experience where one can see huge mountains of marble and a beautiful waterfall. On a rocky hilltop on the western outskirts of the city is the Madan Mahal Fort, built in 1116. The central Rani Durgavati Museum displays intricately carved sculptures. Bargi Dam, Maikal Resort, Dumna Nature Reserve Park etc. are very unique point of attraction in Jabalpur.

III. LAKES IN JABALPUR.

In the long lineage of gond rulers, after king Sangram Shah, the next famous ruler was Rani Durgavati, who ruled Garha-Jabalpur region for 16 years between 1548 to 1564. Most of the water bodies of this region were constructed during this period. Rani Durgawati constructed many lakes and reservoirs, The Gond kings invested their vision to make and preserve the lakes as an important source of water. Some of lakes e.g. Sangram Sagar, Adhartal, Ranital, Mahraj Sagar, Hanuman Tal, Suraj Tal, Imarti Tal, Ganga Sagar, Devtal, Phool Sagar, Soopatal etc. were built in this period. These lakes and pond were built to cater the needs of scattered population. It is said that at that time more than 130 ponds or lakes were in the town. Now only nearly 36 polluted ponds are remaining. Most of the lakes e.g. Cherital, Supatal, Madfaiya lake, Hathital, Bhanwartal, Madhatal, Shreenath ki talaiya, Phuta Tal, Beni Singh ki Talaiya, Tilakbhumi ki Talaiya etc. were reclaimed by the garbage waste, municipal solid waste (MSW) and reclaimed areas are encroached by the people or developed by the builders and colonizers. A major part of the population settled on these areas by making non engineered and poor quality houses to live and such house become sensitive with regard to earthquake and settlement of ground.

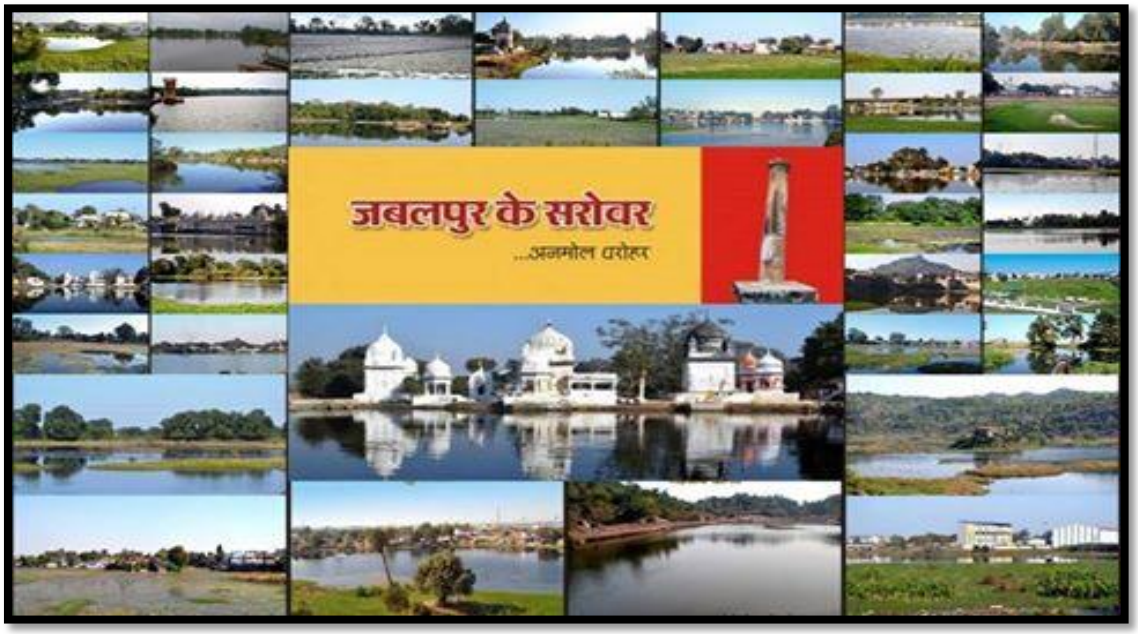

Figure 1 Glimpse of lakes of Jabalpur M.P. *(Courtesy: Jabalpur Ke Sarovar Anmol Dharohar))*

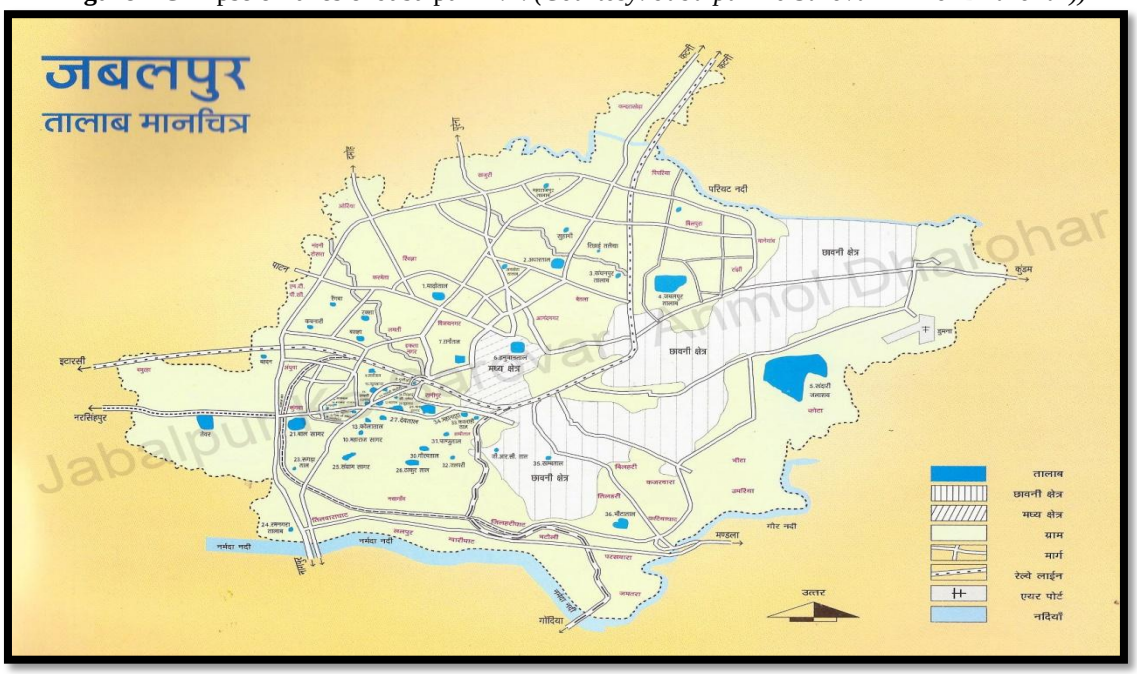

Figure 2 Location Map of lakes of Jabalpur M.P. *(Courtesy: Jabalpur Ke Sarovar Anmol Dharohar))*

Figure 3 Lake boundaries encroached by local residents in Jabalpur.

IV. SEISMICITY OF AREA

The major seismic events in Peninsular India during recent time are the Kutch earthquake of 1819 (M 8.3), Bihar earthquake of 1934 (M 8.4), Koyna earthquake of 1967 (Mb 6.0), Killari earthquake of 1993 (Mb 6.3) and the Jabalpur earthquake of 1997 (Mb 6.0). In addition to these, several earthquakes in the magnitude range 5.0-6.0 occurred in Peninsular India during the last 70 years. The latest Jabalpur earthquake of 1997 falls under zone III of the seismic zoning map of India (IS 1893-1984,). Amongst the earthquakes of the SONATA belt, the prominent one is the Reva (Son valley) earthquake of 1927. The seismicity pattern of the events has a distinct correlation with the ENE –WSW structural features of the terrain. From the earthquake location map it is apparent that many events were recorded in the steeply dipping NSF zone. The main shock of the Jabalpur earthquake of 22 May, 1997 and its aftershocks are also interpreted to have generated as a result of reactivation of the NSF at the crust mantle boundary. It is worth mentioning here that on October 31, 1993 an earthquake of magnitude 3.7 was recorded in the Jabalpur area, west of the epicenter of the earthquake of May, 1997. Epicenter of 1997 earthquake was at a distance approx. 30 Km from the Jabalpur city towards south- east at Kosamghat. Figure 4 showing location of faults

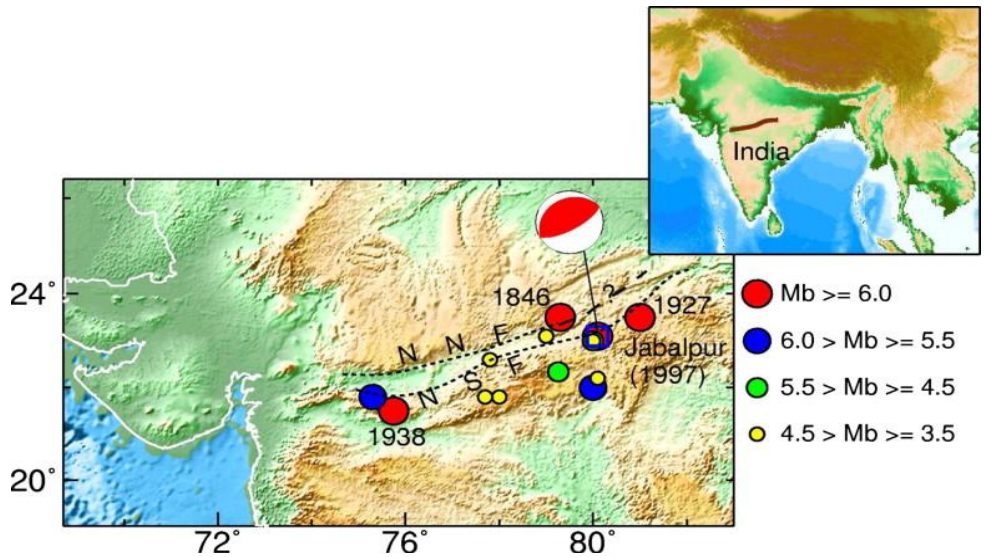

Figure 4 Map showing location of faults in Jabalpur M.P.

V. ASSESSMENT OF LOSSES OF STRUCTURES BUILT ON RECLAIMED LANDS IN JABALPUR

As we discussed earlier about 100 lakes of the town are reclaimed in last 50 - 60 years. The maximum distress due to Jabalpur earthquake was experienced in an area of about 400 $km^{2,}$ which formed the eye of disaster covering historical town of Jabalpur and surrounding villages. This is represented by isoseist VIII which has an elliptical shape with long axis aligned ENE-WSW, encompassing the entire urban area of Jabalpur city and surrounding localities/ villages of Kosamghat, Jamtara - Kuraria, Ghana etc., which suffered the maximum damage. The zone has a length of 32 km extending from Amjhar in the east to Tilwaraghat in the west and a maximum width of 16 km between Ghana in the north and Pararia in the south. The entire Jabalpur urban area falls under isoseismal zone VIII. Maximum damages have been observed in area where the houses were built on reclaimed lands either on low lying area reclaimed or the areas which were developed after reclaim the water bodies. A study has done by author on areas affected in 1997 earthquake and some other structures built on reclaimed land thereafter, described in this paper.

5.1 Gokalpur Area.

This is the area developed mainly on the periphery of one of the biggest lake of the Jabalpur namely Gokalpur lake. The area having about 2000 houses suffered damages. In this area child rehabilitation centre building damaged badly. The residents experienced a strong and frightening tremor. They also witnessed strong swaying of the houses. The earthquake was associated with rumbling sound with vibrations in north south direction. Other localities which fall within this isoseist towards north are, Byoharbag, Ansari Nagar, Nayabasti, Hanumantal, Shantinagar, Lalmati, Ghamapur, Satpula, Central Jail area and G.C.F colony.

5. 2 Ranital Area.

This area located beside Ranital Lake in the central part of the city is densely populated. The people living in this locality felt the shock and

became panicky. In Ranital area lot of structures suffered damages. The building of Allahabad Bank near Ranital Lake damages badly. Shear and tension cracks developed in the walls. The iron doors of the strong room of the bank got jammed. The heavy lockers inside the strong room shifted a few cm towards west. Himgiri apartment- this four storied residential building adjoining Grover Hospital in this area of Jabalpur, tilted on one side and rested against the adjacent building in 1997 earthquake. One of the main RCC pillars of this building broke down causing partial sinking and tilting of the entire structure and caused panic for the residents and neighbors.

5. 3 Gulaua Area

The area is developed on the reclaimed land fill and there are more than 1000 houses. In a three story building the ground floor damages in the form of open shear-conjugate cracks. First and second floor of the building exhibited partial collapse The houses, partial collapse of N-S wall was recorded and portion of the house tilted northward due to differential foundation settlement. Most of the houses were 50 to 100 years old and made from brick and mud with roofs of wooden frames covered by earthen tiles locally known as Khaprail. Some of these houses of without cement plaster weakened due the weathering with the time. Such double storied houses were more vulnerable to earthquake shocks and as a result, most of such houses have suffered partial or total collapse. In a house on Gulaua Chouk-Madan Mahal road, four members of a family, sleeping on the roof of a single storied building, died due to collapse of the wall of an adjoining house. Glimpse and locations of the lakes of Jabalpur are shown in figure 1 and figure 2.

5. 4 Overhead Water Tank & Flyover beside Gulaua Lake.

An over head water storage tank just beside the Gulaua Chouk is a prominent structure. It consists of a 20m high, 6m dia. reinforced shaft, with a 6m high 8m dia. water containing super structure. It has a capacity of one lakh gallons. The tank is founded on fill material by driving 90 numbers of piles. At the time of the earthquake, the tanks were at full capacity and due to dynamic loading following signs of distress were developed.

(i) Three sets of horizontal cracks, 0.30 to 0.60 m apart, along construction joint 0.75m above the ground, were observed on the western perimeter of the shaft.

(ii) 2m long hairline cracks with an inclination of 45° emanated from the crack described above. These are ascribed to torque consequent upon clockwise rotation and inadequacy of shear value considered in the design at that particular

The newly constructed flyover (total length 70.8m) over Itarsi-Jabalpur section of broad gauge railway line consists of 15 piers spread 25m apart on the pile foundation in reclaimed fill. The maximum height of pillars is 26.45m. The bridge has 4 staircases having open foundation. Hairline and wide cracks were observed in the auxiliary decoupled structure like stair cases, parapet wall and guide wall.

5. 5 Gagna Sagar Lake Area.

This area is developed all around the lake Ganga Sagar. Gaga Sagar was a very big lake of the Jabalpur town, encroached by the peoples. About 200 houses of this area suffered damages severely. The damages were recorded from most of the houses. Numerous shear fractures criss-cross the structure and one north-south wall portion tilted by 3cm towards west. Higher grade of damage was noticed along the edges of Ganga Sagar Lake, maximum over thin alluvial cover. The houses over reclaimed lands damage badly. Straight ground cracks a few meters long less than 1cm wide, trending N75°W- S75°E, and straight in nature were observed.

5. 6 Madfaiya Lake and Baksera Talab.

There are about 220 houses settled just on the bank of Madfaiya Lake named Madfaiya muhhalla. Maximum houses damage with the cracks of width up to 2cm. In this locality the houses situated near ponds suffered more damages. During earthquake, people were frightened and heard sounds like explosions and rumbling. At the bank of Baksera Talab there were approx. 125 houses in the locality. Almost all the houses were affected. In the northern outer wall (E-W) shear cracks were observed with 10cm shift towards north. The inner N-S wall also got damaged and tilt of 10° towards west. The pronounced damages were observed near Baksera Talab.

5.7 Imarti Talab, Phool Sagar Lake.

Imarti talab is located in the area Garha Purwa a dense locality of Jabalpur. This area developed besides the lake on land reclamation. Out of total 210 houses in the locality, all the houses were affected by the earthquake. The effect of earthquake damages was comparatively less in nearby Madan Mahal granite area than the area of beside Imarti tank soil cover. Phool Nagar is developed beside the Phool Sagar Lake. There are approx. 400 houses in the locality out of which 320 houses are suffered by large damages. So many damages have been shown in walls, staircase, parapet, etc. The N-S wall of some residence viewed a shift of 2 cm towards east. Both ground and first floor were damaged equally. It is important to mention here that in Phool Sagar locality the damages were more pronounced in N-S direction than in the E-W direction. The locality probably settles on old reclaimed pond area and hence damages were pronounced. Encroachments by residents on boundaries of lakes of Jabalpur are shown in figure 3.

5.8 Bagha Talab and Supatal Lake Area

These areas are developed beside the Bagha Talab and Supa Tal. Maximum area of this locality settled on reclamation of pond area. There are approx. 500 houses around Bagha Talab from which about 400 houses were affected by major damages and about 100 suffered minor damages. In Supatal area there are approx. 200 houses in the locality from which 160 houses damaged badly. A house situated on hill slope damages totally. Due to collapse of an inner pillar one girl was died in this area. In The outer wall a shift of 5cm towards west (tensional opening) was observed. On the hill top, wide cracks at the margins and fine cracks in the central area were noticed trending in random directions.

5.9 Sanjeevani Nagar Area

This locality is situated around a big lake known as Shahi Talab. About 5000 houses of all class were damaged in this area. The Geological Survey of India office building was subjected to varying degree of damages. Though it is a well constructed structure with column and beam, filler walls developed cracks at the wall corners. Slab parallel and shear cracks were also seen. Similarly, the Geological Survey of India colony and Income Tax colony quarters were damaged with various grades. In Geological Survey of India residential colony, there are 41 quarters; out of these 38 is G+1 house damage badly. The foundations of the structures have been raised on reclaimed fill. The quarters are aligned with their long walls in NE-SW and NW-SE directions.

The single storied quarter of the director, developed cracks in some of the walls and plaster fell down at a few places. An open crack developed at the junction of NE-SW facing boundary wall and the R.C.C, pillar of the structure. It is important to note that single storied buildings and specially those on old embankment of the fill have damages of lower grade, whereas the multi-storied structures located on the central part of reclaimed area have pronounced damages.

5.10 Seven Story Building Collapse near Cherital Lake in Jabalpur M.P.

A seven storey under construction building recently collapses down on 17 August, 2016 in Jabalpur. On preliminary observation it was found that apart from the unsafe structural design, the building was constructed at a location Sangam colony near Cherital Lake, which was reclaimed earlier by garbage and waste material. Approximately 100 labors were serving for the construction work and fortunately no causality happens because, for the celebration of Rakshs Bandhan festival all labor came out from this building, one day before this collapse, otherwise this might be a very big accident. So many similar cases are the evidence of such types of disaster on reclaimed lands in Jabalpur. Pictures of collapsed building and other structures damaged in 1997 earthquake are shown in figure 5 and 6.

Figure 5 A seven storey building collapsed near Cherital Lake in Jabalpur

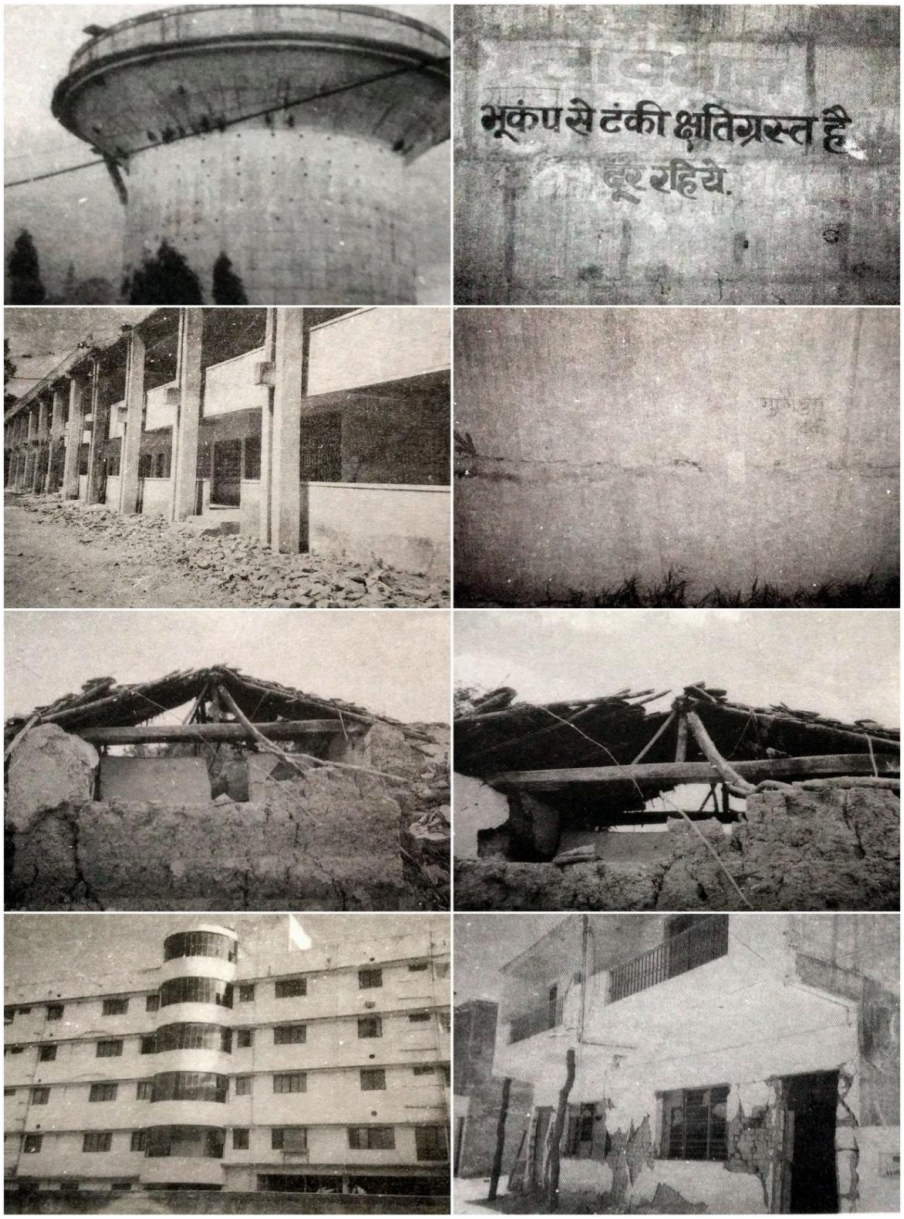

Figure 6 Pictures of some structures built on reclaimed lands damaged in 1997 earthquake in Jabalpur M.P.

VI. RESULTS AND DISCUSSION

On study of the risk assessment of structures built on reclaimed land in Jabalpur M.P. in earthquake May 22, 1997 and afterward, it has been observed that maximum damages took place on such places where the houses were built on reclaimed lands. We have discussed very limited examples in this paper, List of disaster of similar nature is too long. Cheri Tal, Madhatal, Haathital, Kakrahi talaiya, Sagda Tal, Mahanadda, Marhatal etc. are so many land reclaimed locations in Jabalpur, where damages were at higher level. Non engineered land reclamation is always risky because such lands if not properly improved for construction, possibilities of tilting, unequal settlements and even liquefaction of structures may be occur there. Level of disaster may be higher particularly in the earthquake prone area like Jabalpur.

VII. CONCLUSION

Jabalpur is a city of lakes had 136 lakes once upon a time, so many non engineered structures built on these lakes after reclamation. Maximum damages and losses were observed after 22 May 1997 earthquake in such areas where major non engineered structures were built on reclaimed lakes areas. Jabalpur is a seismically prone area comes under Zone III, so situation is very sensitive and we could not ignore the possibility of big losses in future if similar construction will happen further. So many cities of our country are in the race of infrastructural development. Availability of land for such developments is a big challenge. Sometimes in this

fast race we missed some basic points for safe and stable developments. Safe and stable infrastructural development should be on first priority. If land reclamation is the only option to create places for development, it should be properly prepared by applying appropriate ground improvement methods, modern geotechnical applications, advance techniques, advance materials and latest methods for ground improvement. All measure should be implemented for the safe and stable constructions.

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