EVALUATION OF LIQUEFACTION POTENTIAL STUDIES AT JABALPUR:SOME ILLUSTRATIONS

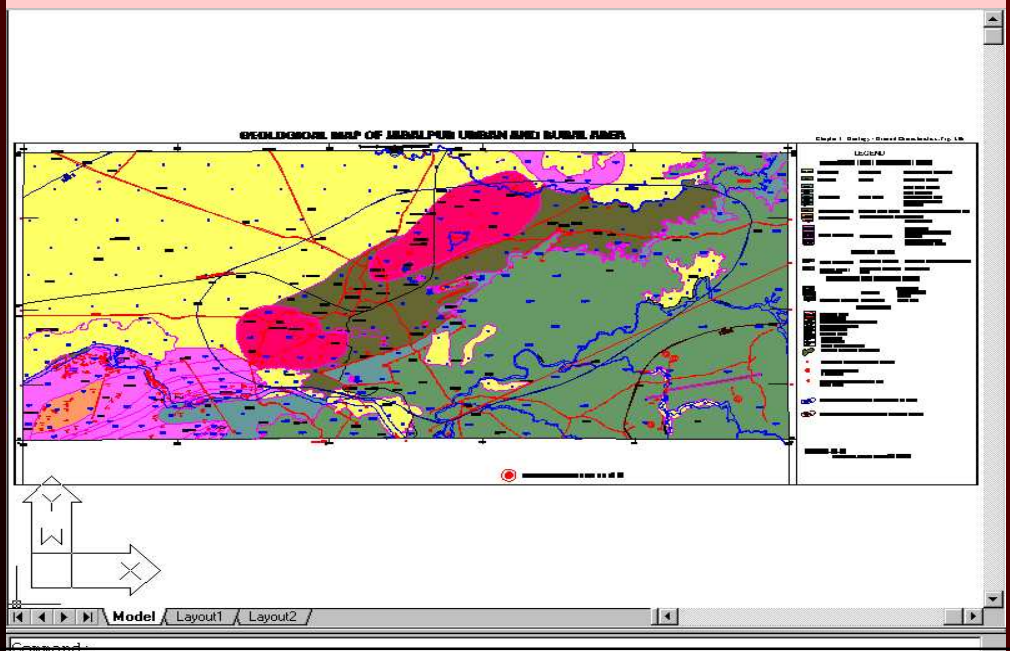
M.Chandra Das, S.D.Pimprikar

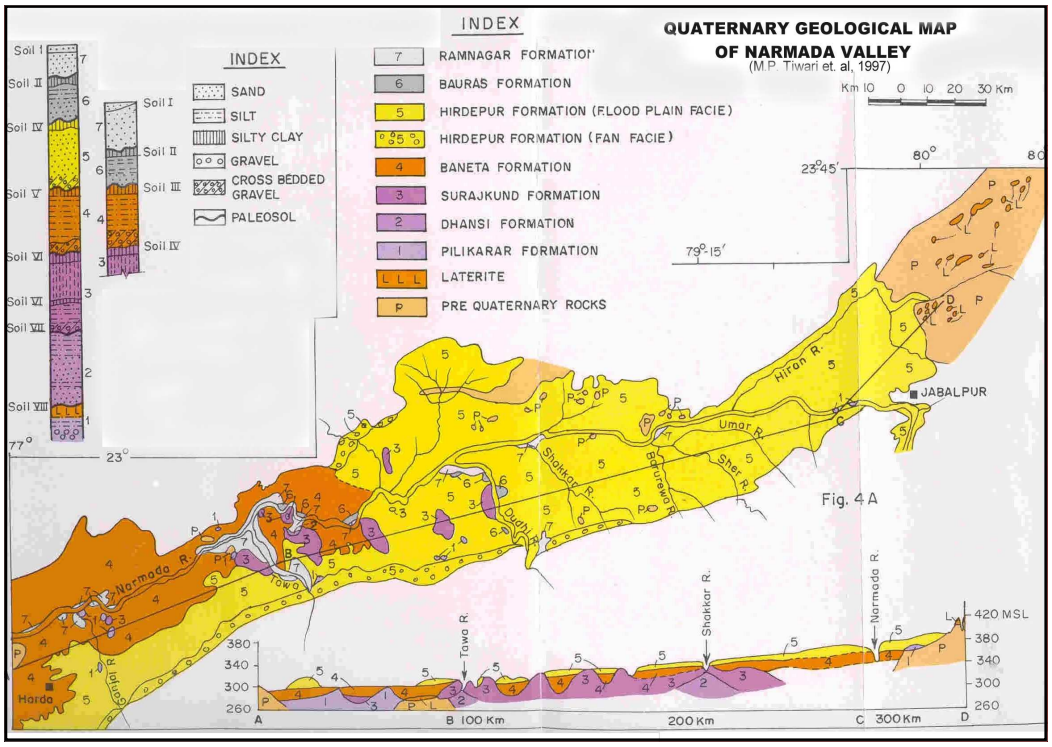
Geological Survey of India

P S Mishra (Retd Director,GSI)

EREC, IMD. New Delhi

GEOLOGICAL MAP OF JABALPUR URBAN AND RURAL AREA





Quaternary Cover Sediment of Jabalpur

There are four unit forming the cover sediment of Jabalpur.

- Pilikarar Fm exposed around Binaki.
- Baneta Fm exposed along Thalwage of Narmada river Saraswathi ghat.
- Hirdepur Fm exposed in river bank.
- Ramnagar Fm exposed in N-NE along Pariat river

21 Ground Characterization: Methodology & Salient Findings

QUATERNARY SUCESSION OF JABALPUR AREA

AGE	FORMATION		LITHOLOGIC ATTRIBUTES	STRUCTURE	CEMENTATION/ OXIDATION	REMARK
HOLOCENE	RAM NAGAR FORMATION		Grey/dark grey, cohesionless, poorly graded, sandy silt and clayey sand, occasionally cross bedded, locally gravel at the base.	Non-bedded/ poorly bedded with occasional small scale cross beds.	Weakly lithified &devoid of calcite cement and oxidation.	Alluvial flood plain and channel bar deposits, mostly SC and ML type &pockets of SW soil; likely: liquefiable. Type area: Pariat river section
UPPER PLEISTOCENE	HIRDEPUR FORMATION	UPPER	Yellowish grey mostly fine-grained non-cohesive sand and silt with none to low plasticity.	Micro cross laminations	Low oxidation / incipient calcite cementation	Vertical accretion; loess like material, cohesion less mostly ML type, form extensively dissected terrain along trunk streams. Type area: Saraswati Ghat section.
		MIDDLE	Yellowish grey well laminated/ thin bedded; moderate to low scale cross beds with abundant pene-contemporaneous deformations sand dykes and detached claystone balls; calcareous concretions and Caliche layers.	Medium scale planar/ trough cross beds, abundant palaeo seismic signatures.	Low oxidation and abundance of calcrete and calcite cement.	weakly cohesive alluvial fill- sand bars with lateral accretion ; dominantly SC and SP type soil with minor ML/CH bands; likely liquefiable. Type area Gopalpur and Saraswati Ghat.
		LOWER	Yellowish grey ,well bedded/,profusely cross bedded ,coarse medium sand poorly graded with bands of clay sand; moderately cohesive.	Large scale cross beds burrows.	Low Oxidation profuse calcrete and extensive calcite cementation	Cohesive alluvial fill sand bar deposits mostly SP with CH inter-laminations. Poorly / non liquefiable
	BANETA FORMATION		Yellowish/Reddish yellow oxidized sand- gravely sand with alternations of poorly graded calcite cemented gritty sand and matrix supported conglomerate and subordinate basal unit of non -laminated ferruginous clay /clay stone.	Extensive cross bedded large scale planner and trough cross bedded.	Moderate to high oxidation locally fericretes extensive calcite cementation locally ferruginous cement.	Cohesive indurated & cemented GC GP SP and CH type of soil non liquefiable type area Saraswati Ghat abandoned channel.
	PILIKARAR FORMATION		Massive pisolitic and fericreted sequence with sandy horizon and ferruginous claystone.	Massive large scale cross beds rarely seen.	Extensive development of oxysalts and fericrets.	Cohesive hard fericreted GP; non-liquefiable; type area Binaiki.

Soil Cover Sediment of Jabalpur

Jabalpur lies close to tropics, mainly four types of soil found in Jabalpur urban area.

- Entisol characterised by incipient development of the soil with undecomposed vegetal matter developed along flood plain and Deccan trap; GP type soil V_S = 500m/s.
- Inceptisol well developed O horizon, seen over weathered granite, Gondwana rock; Soil type GP-SC V_S = 400 m/s.
- Vertisol Dark grey Blocky clay soil, no developed soil profile, significance as regards to Liqefaction susceptibility V_S = 200 m/s.
- Podosol well developed over soft sediments soil essentially sand;SP type V_S = 150 to 500 m/s.

SOIL TYPES OF JABALPUR URBAN AREA									
Soil Type	Seventh approximation of USA	Colour	Texture	Structure	Dry Consistency	Cutan	Concretion	Type	Distribution
I	Entisol	Grey to Dark grey	Loamy sand	Single gram	loose hard	Nil	Nil Rarely seen	Locality along Pariat river Dumna Gadheri Rampur	To surface over Ramnagar and over DTUP DTDP
II	Inceptisol	Dark grey to grey	Clay and clayey silt	Strong prismitic	hard	nil	Rarely seen	Khamaria	Soil form over granite/Gondwana
III	Vertisol	Dark grey	Clay and clay clayey silt	Block like	hard	nil	Calcareous	North-western part of Jabalpur	Soil developed over Hirdepur Fm and Deccan trap formation
IV	spodosol	Dark grey	Sandy clay silt stand	Massive	hard	Clay cuton	nil	Saraswathi ghat Khamaria, Piparia,	Palaeosol of Baneta Fm, Soil profile well developed
V	Oxisol	Fericrete, Laterite, and clay	Probabilistic sand & gravel size	Massive	hard	----	Ferruginous	Pilikarar formation near Binaki	Soil over Gondwana Sst Pilikarar formation

EVIDENCE OF LIQUEFACTION IN JABALPUR

- During Jabalpur earthquake signature of liquefaction related phenomena viz.
- Sand Blows
- Gas emanation
- Retrogressive slope deformation due to lateral Spread have been noticed

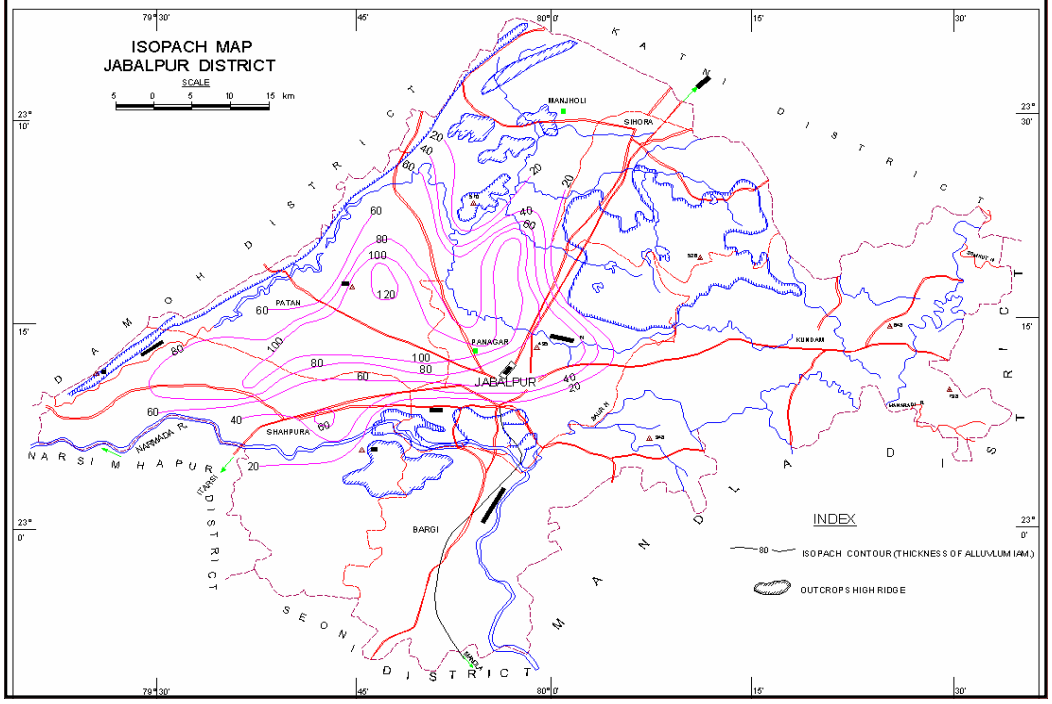
Palaeo-seismic evidence of Liquefaction seen at saraswathy ghat near BheraGhat

Dried up and collapsed Craterlet on Silted Bargi Reservoir, formed due to Methane Gas emanation

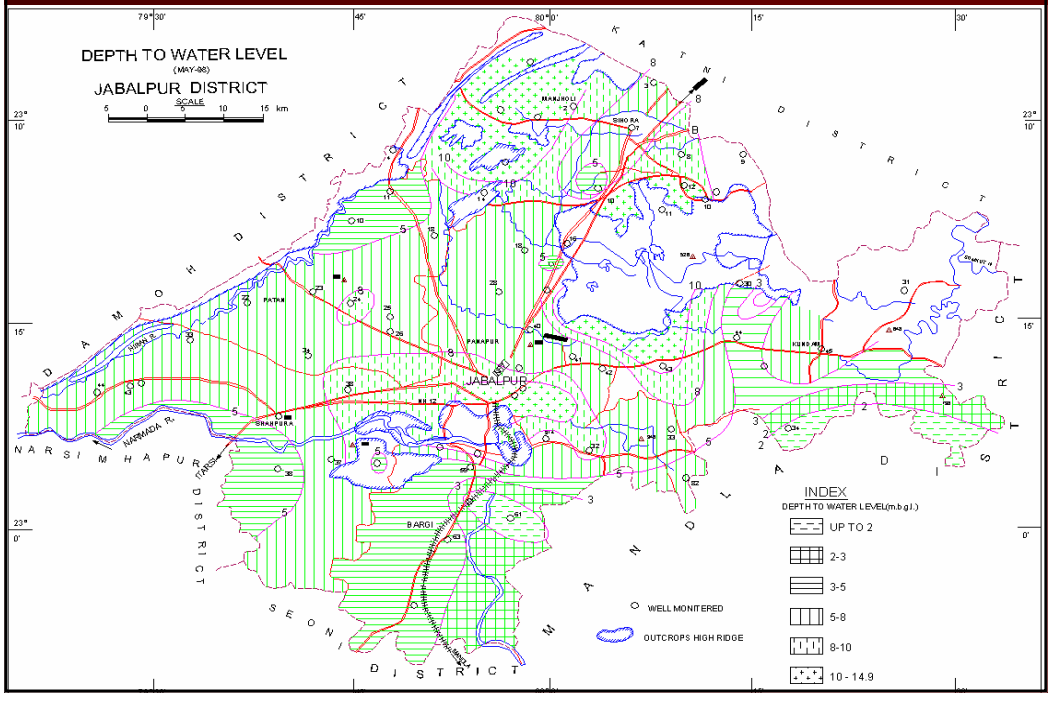
Active Gas emanation from craterlet Chiraidongri, Mandla

Retrogressive circular shear failure in emerged silt, near Chiraidongri on Bargi reservoir

BASIN CONFIGURATION OF ALLUVIAL FILL IN JABALPUR DISTRICT



DEPTH TO WATER LEVEL (bgl) – PRE MONSOON



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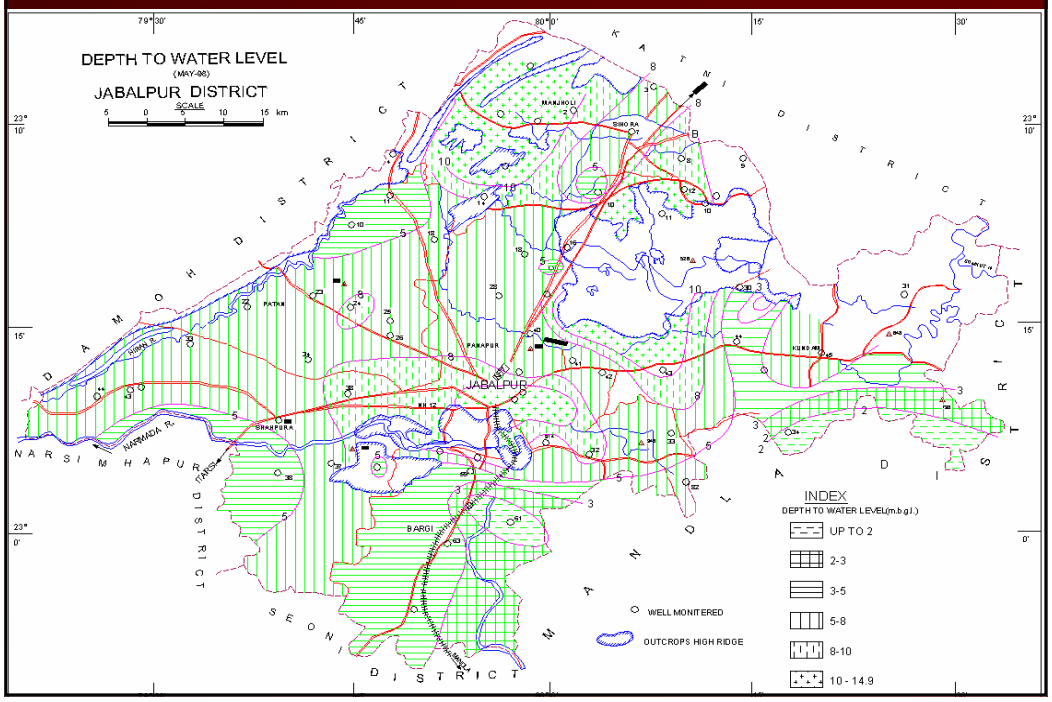
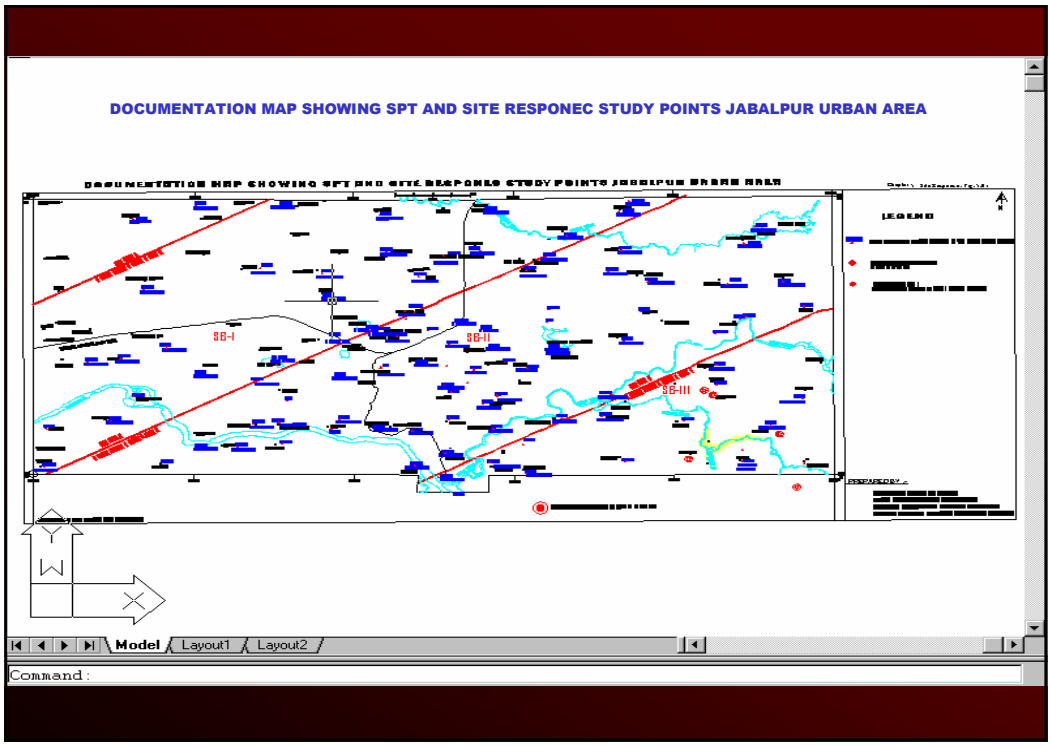


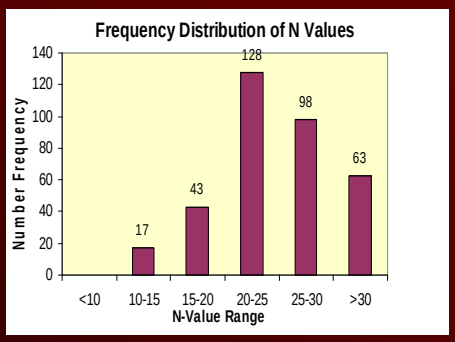
Geotechnical Studies

- 97 SPT Test were conducted and N value obtained from these bore holes were corrected for: over burden, borehole diameter Rod length, hammer energy ratio.
- In addition to above correction silt correction is also done.
- D_{50} Sediment > 0.25 mm no correction, <0.15 mm 7.5 in added to modified n value between 0.25mm and 0.15mm we increase the corrected N value linearly.
- N valve obtained have been modified to equivalent clean sand value of penetration**.**

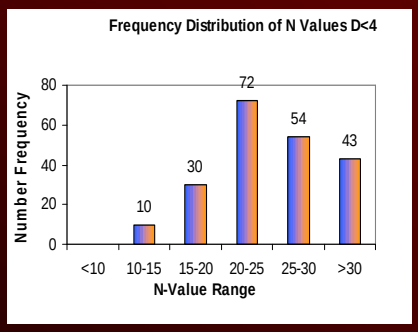


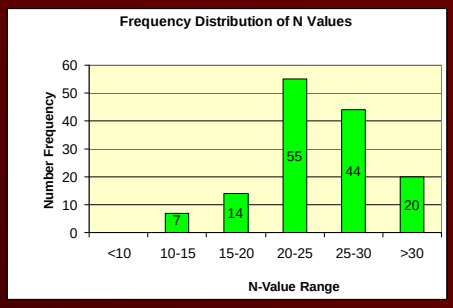
N Values and Their Distribution in Jabalpur

- **Modified N values (N60) obtained from SPT data used for evaluating liquefaction susceptibility.**
- **For each SPT test cyclic shear resistance ratio have been computed.**
- **Calculations as per the recommended methodology in IS.2131-1981 and enunciated by Seed and Idriss (1982) and Idriss (1990).**

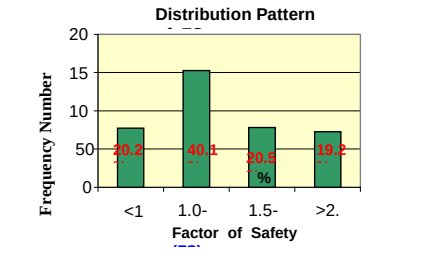


- **Cover sediment of Jabalpur area, characterised by >20N.**
- **Modal class of 64% between 20 and 30 N.**
- **N values less than 20, which are likely to indicate liquefiable material, constitute only less than 20% of the total tested sections.**



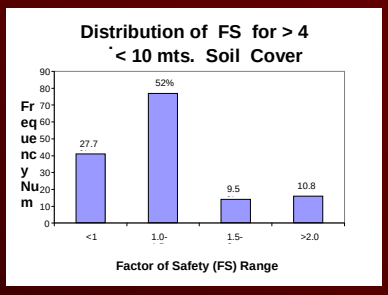


- **Similarly, (i) for depth less than 4m and (ii) more than 4m, the dominant N values between 20-30 modal percentile are 60 % and 70% respectively**
- **N values less than 20, which are likely to indicate liquefiable material, for (i) for depth less than 4m and (ii) more than 4m, computed value is 19% & 15% respectively.**



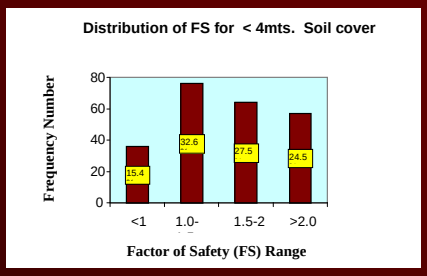
Cover sediments of Jabalpur area are characterized by low liquefaction susceptibility.

- **Total SPT at 97 points.**
- **20% of the tested sections are highly susceptible to liquefaction.**
- **40% have moderately susceptible range.**
- **40% have low to very low susceptibility.**



FS values for sediment sections of >4m in depth.

- 28% show highly susceptibility to liquefaction.
- 52% are moderately susceptible
- 20% have low to very low susceptibility



Values of FS for sediments < 4m depth.

- 15% of the tested sections are highly susceptible to liquefaction;
- 37% of them are moderately susceptible where as
- 52% are low to very low susceptible

- **Methodology by Ishihara (1985) is followed and Fs value derived for post monsoon scenario is taken into consideration.**
- **Thickness of LQ layer compared with thickness of the layer.**
- **FS value derived for post monsoon scenario have been plotted to decide whether response of liquefiable layer will or will not cause damage to ground surface,**
- **Thickness of liquefiable layer can be compared with thickness surface of crust using the criteria.**
- **It is found that high liquefaction is possible in SB II GLSS domain where vulnerable liquefaction would be manifested even for low PGA 0.20 (amplified) .**

- **Even central part of Jabalpur between two granite tor, having high density of building with shallow foundation are highly vulnerable.**

- **Lateral spreading may take place area proximal to Omti and Khandari nala.**

DISCUSSIONS

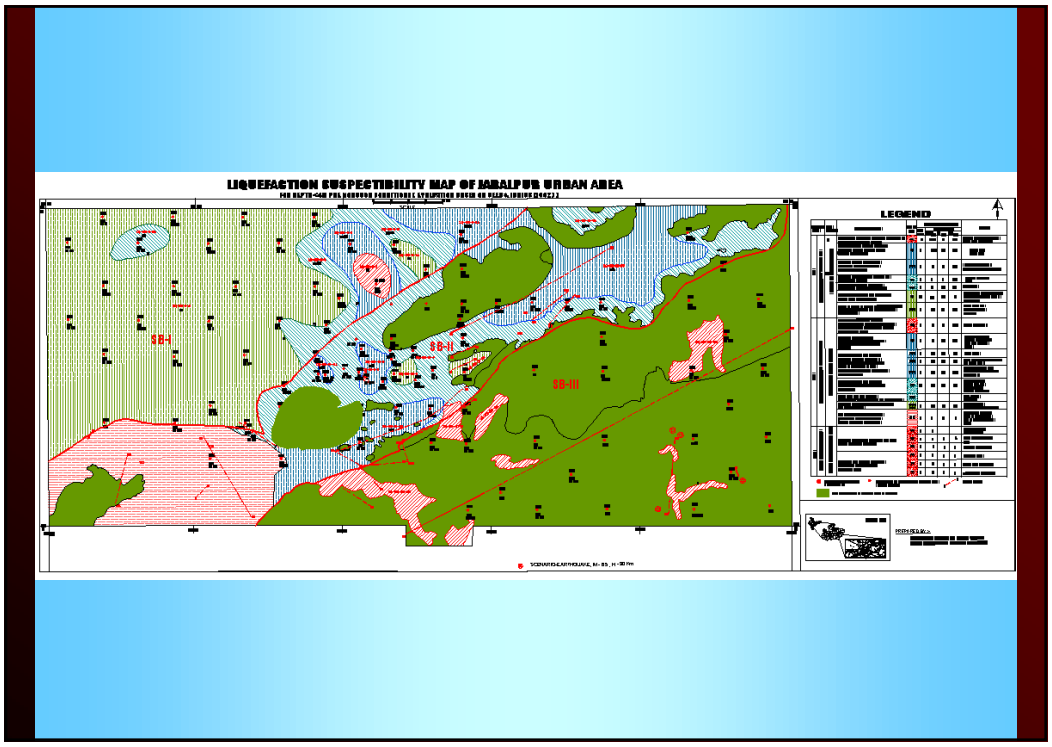
- **Modified N values obtained from SPT data is used for calculating CSR following the methodology recommended in BIS 2131-1981 enumerated by Seed and Idriss.**
- **Cover sediment of Jabalpur area characterised with modal clan of 77% between 20 to 30 N.**
- **N value range about 62% for N 20-30 when considered for <4m.**
- **In Holocene soil profile developed over Gondwana sediment, the N value < 20 is much higher compared to soil cover over Alluvial fills.**
- **In case of Alluvial fill value is much lower at depth compared to surface then may be attributed to pedogenesis and secondary conditions.**

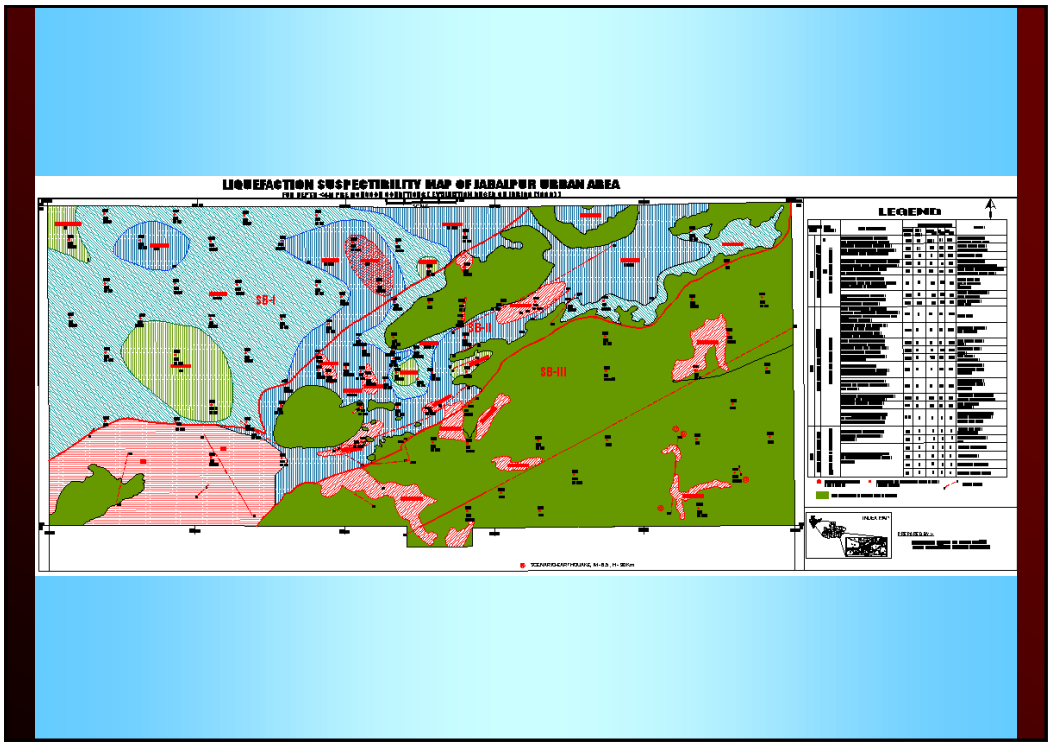
Four LQ Susceptibility maps have prepared.

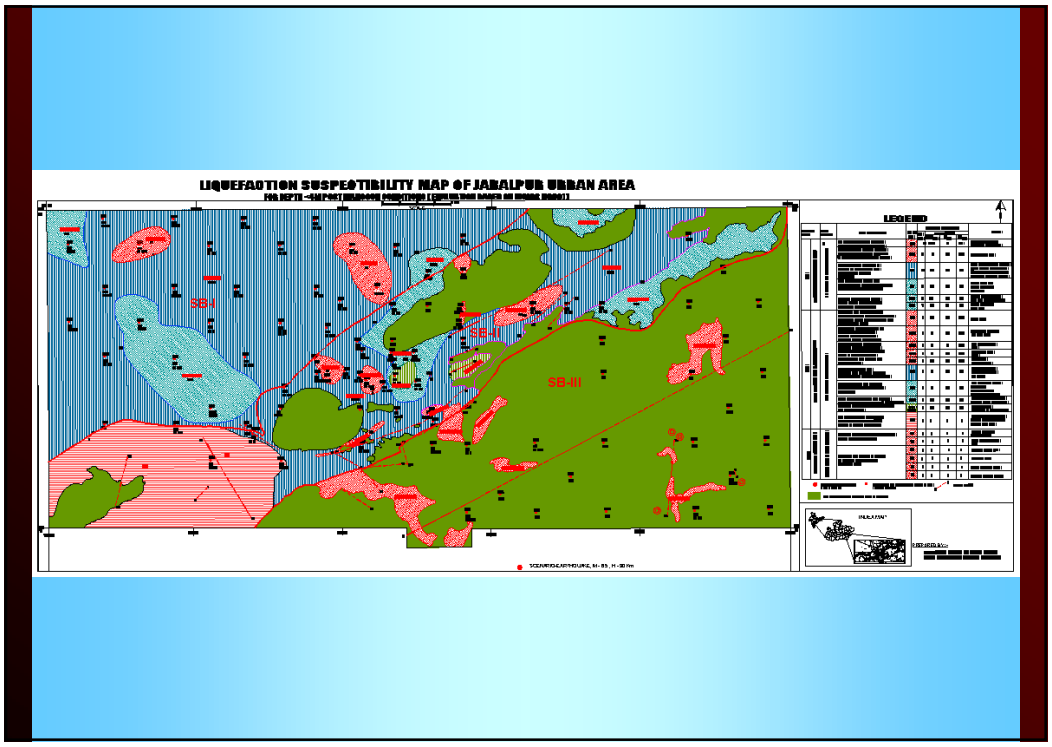
1. **LQ susceptibility map for 4m depth pre monsoon and Idriss.**
2. **LQ susceptibility map 4m depth pre monsoon Idriss (1990).**
3. **LQ susceptibility map 4m depth post monsoon - Idriss.**
4. **LQ susceptibility map 10m depth post monsoon Idriss.**

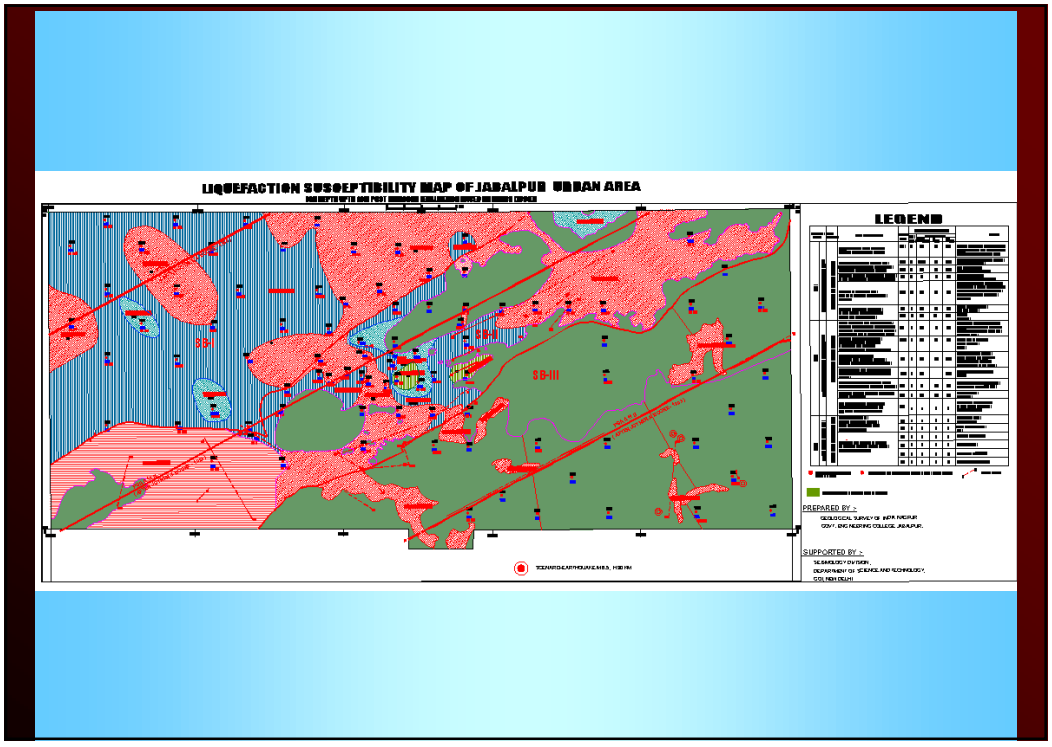
Comparing these (Seed and Idriss 1982 & Idriss (1990)

- **For 4m pre monsoon condition:**
  - **In former- the LQ zone is restricted to small unit around Uldana and Wright Town**
  - **Alluvial fill in DTUP due to proximity to epicenter.**
- **In Idriss method more areas have come under LQ unit.**


LIQUEFACTION SUSCEPTIBILITY MAP OF JABALPUR URBAN AREA
LEGEND
SB-I
SB-II
SB-III


LIQUEFACTION SUSCEPTIBILITY MAP OF JABALPUR URBAN AREA
LEGEND
SB-I
SB-II
SB-III


LIQUEFACTION SUSCEPTIBILITY MAP OF JABALPUR URBAN AREA
LEGEND
SB-I
SB-II
SB-III


LIQUEFACTION SUSCEPTIBILITY MAP OF JABALPUR URBAN AREA
LEGEND
SB-I
SB-II
SB-III
PREPARED BY :-
SUPPORTED BY :-

CONCLUSION

- LQ Scenario as observed in for 10m depth and post monsoon conditions-
  - ✓ Large area of Jabalpur comes under LQ susceptibility.
  - ✓ However, the area does not have the opportunity for liquefaction due to absence confining pressure conditions.

- Jabalpur has been classified into 19 susceptible unit of which 11 have Fs value <1 and have been critically studied.