А.А.Гусев.
Подборка иллюстраций и литературных ссылок и цитат по вопросу дифференциальных осадок/просадок оснований как причин повреждений и разрушений зданий
22.01.2012.

Это быстрая и в общем почти случайная подборка легкодоступных иллюстраций и цитат по вопросу опасности от дифференциальных осадок оснований зданий и сооружений при землетрясениях. Просьба иметь в виду, что часто данное явление идет под рубрикой «разжижение грунта» или «потеря несущей способности грунта». Аналогичный характер имеет опасность от боковых сдвигов сооружений как целого, поверх грунта или вместе с грунтом.
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(1) Juliet F. BIRD, Rodolfo SANCIO, Jonathan D. BRAY & Julian J. BOMMER
THE GROUND FAILURE COMPONENT OF EARTHQUAKE LOSS ESTIMATIONS: A CASE STUDY OF ADAPAZARI, TURKEY. 13th World Conference on Earthquake Engineering , Vancouver, B.C., Canada August 1-6, 2004 Paper No. 803

Figure 1: Tilted building due to liquefaction in central Adapazari.

In Adapazari ... Visible structural damage was in the form of cracks, deformations or collapse; **and foundation damage was in the form of uniform or differential settlement, often accompanied by bulging of foundation soil or occasionally, lateral foundation displacements of up a metre**.

See also

Bird JF, Bommer JJ “Evaluating earthquake losses due to ground failure and understanding their relative contribution” 13WCEE, Vancouver, 2004, Paper No. 3156
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http://pubs.usgs.gov/of/1996/ofr-96-0263/groundf2.htm

<lessons of Northridge 1994 earthquake>

The foundation slab of this 1-story single-family home in the Balboa Blvd. area was damaged by small settlement and extensional ground cracking that is evident in the lawn (arrow, foreground). Structural damage to the foundation was so extensive that the home had to be demolished.

In the study area, 4,829 homes experienced some reported property loss and the kinds of required repairs are known for 2,983 of them. Repair costs for all properties range from $200 to $381,000, averaging $12,193 per property. However, average repair costs for the 315 properties in areas affected by ground failure were about 300 percent higher than for the 4,514 properties outside of ground-failure zones. **The higher costs in ground-failure zones were largely due to major foundation repairs, and demolition and replacement of buildings where foundations were also damaged. Furthermore, most structures that experienced significant losses were typically located on or near zones of mapped ground cracks.**

Ground failure, rather than ground shaking, is the principal cause of damage to water and sewer lines. The brittle sewer pipes tended to fail under much lower strains than water lines, so damage to sewer lines is considerably more extensive. Identifying where and to what degree subgrade utilities are at risk from earthquakes can be accomplished by accurately delineating regions at risk of ground failure during earthquake shaking.

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http://www.nibs.org/client/assets/files/bssc/nehrp2003_C7.pdf

Liquefaction hazard. Liquefaction of saturated granular soils has been a major source of building damage during past earthquakes. Loss of bearing strength, differential settlement, and horizontal displacement due to lateral spreads have been the direct causes of damage. Examples of this damage can be found in reports from many of the more recent earthquakes in the United States, including the 1964 Alaska, the 1971 San Fernando, the 1989 Loma Prieta, the 1994 Northridge, the 2001 Nisqually, and the 2003 Denali earthquakes. Similar damage was reported after the 1964 Niigata, the 1994

Hyogoken-Nanbu (Kobe), the 1999 Taiwan, and the 1999 Turkey earthquakes.

Loss of bearing strength. Loss of bearing strength can occur if the foundation is located within or above the liqefiable layer. The consequence of bearing failure could be settlement or tilting of the structure. Usually, loss of bearing strength is not likely for light structures with shallow footings founded on stable, nonliquefiable materials overlying deeply buried liquefiable layers, particularly if the liquefiable layers are relatively thin. Simple guidance for how deep or how thin the layers must be has not yet been developed. Martin and Lew (1999) provide some preliminary guidance based on the Ishihara (1985) method. Final evaluation of the potential for loss of bearing strength should be made by a geotechnical engineer experienced in liquefaction hazard assessment

Ground settlement. For saturated or dry granular soils in a loose condition, the amount of ground settlement could approach 3 to 4 percent of the thickness of the loose soil layer in some cases. This amount of settlement could cause tilting or cracking of a building, and therefore, it is usually important to evaluate the potential for ground settlement during earthquakes.

Tokimatsu and Seed (1987) published an empirical procedure for estimating ground settlement. It is beyond the scope of this commentary to outline that procedure which, although explicit, has several rather complex steps. The Tokimatsu and Seed procedure can be applied whether liquefaction does or does not occur. For dry cohesionless soils, the settlement estimate from Tokimatsu and Seed should be multiplied by a factor of 2 to account for multi-directional shaking effects as discussed by Martin and Lew (1999).

Lateral spreads. Lateral spreads are ground-failure phenomena that can occur on gently sloping ground underlain by liquefied soil. They may result in lateral movements in the range of a few centimeters to several meters. Earthquake ground-shaking affects the stability of gently sloping ground containing liquefiable materials by seismic inertia forces combined with static gravity forces within the slope and by shaking-induced strength reductions in the liquefiable materials. Temporary instability due to seismic inertia forces are manifested by lateral "downslope" movement. For the duration of ground shaking associated with moderate-to large-magnitude earthquakes, there could be many such occurrences of temporary instability during earthquake shaking, producing an accumulation of "downslope" movement.

7.4.3 Foundation ties. One of the prerequisites of adequate performance of a building during an earthquake is the provision of a foundation that acts as a unit and does not permit one column or wall to move appreciably with respect to another. A common method used to attain this is to provide ties between footings and pile caps. This is especially necessary where the surface soils are soft enough to require the use of piles or caissons. Therefore, the pile caps or caissons are tied together with nominal ties capable of carrying, in tension or compression, a force equal to SDS/10 times the larger pile cap or column load. A common practice in some multistory buildings is to have major columns that run the full height of the

building adjacent to smaller columns in the basement that support only the first floor slab. The coefficient applies to the heaviest column load.

Alternate methods of tying foundations together are permitted (such as using a properly reinforced floor slab that can take both tension and compression). LA common practice in some multistory buildings is to have major columns that run the full height of the

building adjacent to smaller columns in the basement that support only the first floor slab. The coefficient applies to the heaviest column load.

Alternate methods of tying foundations together are permitted (such as using a properly reinforced floor slab that can take both tension and compression).

http://www.crid.or.cr/cd/CD_BivaPaD/pdf/doc546/doc546_3d.pdf

Pisco earthquake, Peru, August 15, 200

Fig. 3.23. Close up of hotel damage. Relative ground movement, due to liquefaction, between the columns of the exterior roof structure and the building, caused the cracks.

Fig. 3.25. Settlement of 0.7 m of building in front of palm tree.

Fig. 3.28. Foundation pushed up due settlement the building.

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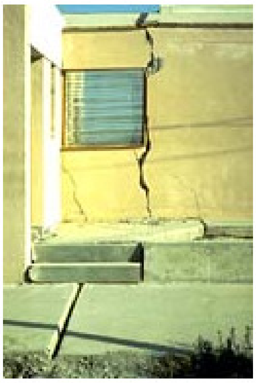
http://nisee.berkeley.edu/bertero/html/damage_due_to_liquefaction.html#j13-14

J16. One-story masonry house in a main housing development in the town of Caucete, damaged due to differential settlement caused by liquefaction in the 1977 Caucete Earthquake.



J20. This one-story wood frame dwelling slid on its foundation by approximately 1.0 m during the 1983 Coalinga Earthquake.

J42. Damage to foundation of a house in the town of Wakami, Akita Prefecture in Japan during the 1983 Nihonkai-Chubu Earthquake [10, 11]. Damage was due to lateral ground spreading of loose saturated granular soils and inadequate reinforcement of the foundation tie beams.

J45. Oga Technical High School, 1983 Nihonkai-Chubu Earthquake. Reinforced concrete door steps, cantilevered from RC grade beams supported on the pile caps illustrate clearly the significant settlement of the soil due to liquefaction.

J46. Oga Technical High School, 1983 Nihonkai-Chubu Earthquake. Because it was constructed on properly designed pile, this gymnasium did not suffer any damage in spite of the fact that the ground soil liquefied and settled in some places by 0.50 meters (see Slides J18, J44 and J45).

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http://db.nzsee.org.nz:8080/c/document_library/get_file?uuid=7b514d94-872c-4c37-aae9-75efcafdd297&groupId=10533

(b)

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http://books.google.ru/books?id=X8hEt3l1SPQC&pg=PA614&lpg=PA614&dq=%22ground+settlement%22+earthquake++damage&source=bl&ots=4H8iQ8sHvg&sig=Vj-NQj6LyqqEwVWAxhJhuy3Mjgo&hl=ru&sa=X&ei=t5gbT5C_Ns2c-wax9_iyCg&ved=0CCEQ6AEwADgK#v=onepage&q=%22ground%20settlement%22%20earthquake%20%20damage&f=false

Foundation engineering handbook

Авторы: Hsai-Yang Fan

Ground settlements due to compaction often lead to differential settlements of engineering structures—a phenomenon that is particularly well illustrated by the performance of bridge abutments. Often an abutment is supported on firm materials or on a pile foundation and undergoes relatively small settlements compared with the backfill material for the abutment, which rests directly on the ground surface and settles due to compaction of the soil on which it rests. Figure 16.2 shows a differential movement of several feet between a railroad bridge abutment and its backfill as a result of the Niigata earthquake of 1964.

In addition to the damage resulting from changes in elevation, differential settlements due to soil compaction and the resulting stresses induced in buildings may well have contributed significantly to the structural damage resulting from earthquakes in some locations. Tests on dry sands have shown that vertical

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International handbook of earthquake and engineering seismology, Part 2, p 1172

Sections on:

5.4 Ground settlement
5.5 Loss of bearing strength

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