Liquefaction

The recent sequence of earthquakes and aftershocks in the Christchurch area has highlighted a phenomenon that previously has had a very low public profile. Now, 'liquefaction' is visible. Its effects in Christchurch are extensive and have resulted in significant damage to property, buildings and infrastructure, not to mention creating a widespread mess. Silt, sand and water bubbled up in people's backyards, in streets and parks and even through the concrete floors of buildings. Some refer to the sand and silt as liquefaction, but that is not correct. The soil at the surface is a result of liquefaction.

WHAT IS LIQUEFACTION AND WHY DOES IT OCCUR?

Liquefaction is the process that leads to a soil suddenly losing strength, most commonly as a result of ground shaking during a large earthquake. Not all soils however, will liquefy in an earthquake. The following are particular features of soils that potentially can liquefy:

- They are sands and silts and quite loose in the ground. Such soils do not stick together the way clay soils do.
- They are below the watertable, so all the space between the grains of sand and silt are filled with water. Dry soils above the watertable won't liquefy.

When an earthquake occurs the shaking is so rapid and violent that the sand and silt grains try to compress the spaces filled with water, but the water pushes back and pressure builds up until the grains 'float' in the water. Once that happens the soil loses its strength – it has liquefied. Soil that was once solid now behaves like a fluid.

WHAT HAPPENS NEXT?

Liquefied soil, like water, cannot support the weight of whatever is lying above it – be it the surface layers of dry soil or the concrete floors of buildings. The liquefied soil under that weight is forced into any cracks and crevasses it can find, including those in the dry soil above, or the cracks between concrete slabs. It flows out onto the surface as boils, sand volcanoes and rivers of silt. In some cases the liquefied soil flowing up a crack can erode and widen the crack to a size big enough to accommodate a car.

Some other consequences of the soil liquefying are:

- Settlement of the ground surface due to the loss of soil from underground.
- Loss of support to building foundations.
- Floating of manholes, buried tanks and pipes in the liquefied soil - but only if the tanks and pipes are mostly empty.
- Near streams and rivers, the dry surface soil layers can slide sideways on the liquefied soil towards the streams. This is called lateral spreading and can severly damage a building. It typically results in long tears and rips in the ground surface that look like a classic fault line.

Not all of a building's foundations might be affected by liquefaction. The affected part may subside (settle) or be pulled sideways by lateral spreading, which can severely damage the building. Buried services such as sewer pipes can be damaged as they are warped by lateral spreading, ground settlement or floatation.

AFTER THE EARTHQUAKE

After the earthquake shaking has ceased, and liquefaction effects have diminished (which may take several hours), the permanent effects include:

- Lowering of ground levels where liquefaction and soil ejection has occurred. Ground lowering may be sufficient to make the surface close to or below the watertable, creating ponds.
- Disruption of ground due to lateral spreading.

The liquefied soil that is not ejected onto the ground surface re-densifies and regains strength, in some cases re-densified soil is stronger than before the earthquake. Careful engineering evaluation is required to determine whether ground that has suffered liquefaction can be redeveloped.

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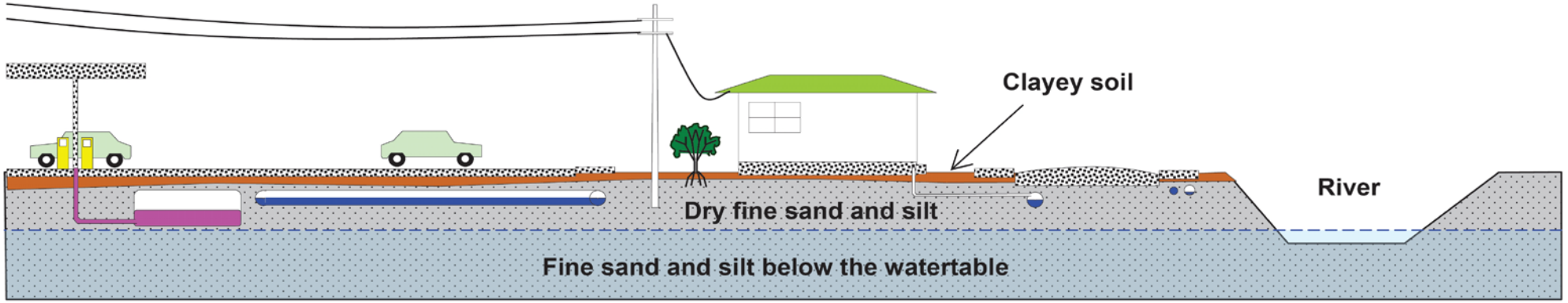
Liquefaction and its Effects

Before the Earthquake

Areas of flat, low lying land with groundwater only a few metres below the surface, can support buildings and roads, buried pipes, cables and tanks under normal conditions.



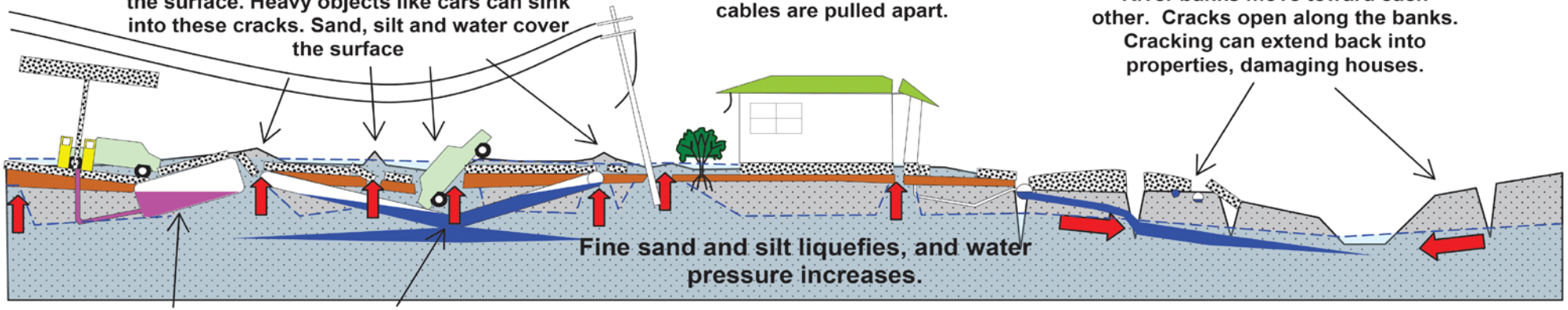
During and after the Earthquake

During the earthquake fine sand, silt and water moves up under pressure through cracks and other weak areas to erupt onto the ground surface. Near rivers the pressure is relieved to the side as the ground moves sideways into the river channels.

Sand Boils (Sand Volcanoes)
Sand, silt and water erupts upward under pressure through cracks and flows out onto the surface. Heavy objects like cars can sink into these cracks. Sand, silt and water cover the surface

Power poles are pulled over by their wires as they can't be supported in the liquefied ground. Underground cables are pulled apart.

Lateral Spreading
River banks move toward each other. Cracks open along the banks. Cracking can extend back into properties, damaging houses.



Tanks, pipes and manholes float up in the liquefied ground and break through the surface. Pipes break, water and sewage leaks into the ground.