TREES AND THEIR EFFECTS ON BUILDINGS

JIM Y.O. LOKE BSc, BE (Hons), PhD, FIEAUST, CP ENG
Principal Engineer, Design and Services, NSW Public Works Department
and
YURGEN E. SEREDIUK, BE, Dip Bld Sc
Senior Engineer, Design and Services, NSW Public Works Department

INTRODUCTION

Since the mid-seventies there has been an emphasis on greening the environment, especially by the planting, often indiscriminately, of trees. Unfortunately, many trees can cause structural problems to buildings, especially in reactive clays if planted too close to the buildings.

Designers and Building Codes in the past, have often overlooked the need to make proper allowances for the effect of trees in the design of buildings.

This paper presents a discussion of the effect trees have on buildings, in reactive clay soils, and looks at methods of designing/allowing for trees and at methods of minimising the effects of trees on existing buildings.

A case study of damage to a building caused by trees is presented.

TREES AND REACTIVE CLAYS

All clays shrink and swell to some degree with changes in moisture content. Reactive clays undergo large shrink/swell movements.

Trees send down roots into soils searching for water and nutrients. As they remove water, the soils, if clays, shrink. In "normal" times when rain regularly replenishes the soil moisture which stays relatively stable, tree roots tend to stay near the surface. However, when there are periods of long dry weather, ie droughts, or when there is competition from adjacent trees, the tree roots go deeper and spread wider in their search for water and so further shrink clay soils.

If a building is constructed nearby, the soil under the building in "normal" times becomes moister than the soil about it as the building minimises cyclic drying out underneath. Thus when long dry periods occur, the area under the buildings is relatively moist and so attracts the tree roots and aggravates the shrinkage problems.

It has been also noted that in "normal" times trees seem to have a relatively greater effect on clays with moderate shrink/swell properties than on clays with extreme shrink/swell properties. This is probably because the seasonal effect of moisture variation in moderate shrink/swell clays is restricted to the upper layers (say 1 metre) whilst that of extreme shrink/swell clays go deeper (to over 3 metres in black soils) and the effect of tree roots is generally accepted to be about 3 metres (though greater depths are not unusual), so the tree roots affect the deep layers of moderately reactive clays more than the extremely reactive clays.

Australian trees have been found to be very adapt at searching for moisture. The species of tree determines its water demand, hardiness and pattern of growth. Deciduous trees have a high water demand in dry warm season and are more likely than evergreens to cause volume changes in the soil.

Common high-water-demand tree species include acacias, ash, willows, gums, cedars, palms, oaks, cypress, figs, pines and poplars.

EFFECTS OF TREES ON BUILDINGS

Trees can affect buildings in many ways.

The most common problem is related to tree root absorption of soil moisture. In reactive clays this causes shrinkage, leading to settlement of footings, cracks in brittle materials, uneven floors, jammed doors and windows and in the extreme potentially unstable buildings.

Uplift due to root growth could be a problem if the tree is very close to the building.

Fallen trees and broken branches, especially during storms is a another potential problem.

METHODS OF DESIGNING/ALLOWING FOR TREES FOR NEW BUILDINGS

The introduction of Australian Standard AS2870 – Residential Slabs and Footings, will undoubtedly reduce the problems associated with trees as the recommended footings for reactive soils are much stiffer than the slab on ground designs previously used. However, the Code's recommendations in Appendix A that trees should not be planted closer than 1½ times the mature height (h) for Class E sites, 1 h for Class H sites and 3/4 h for Class M sites (to reduce but not eliminate the possibility of damage) is not often a practical solution due to the size of suburban blocks and the desire of home owners for a green environment.

Also, as the designer has no control as to what will happen later, some allowance should be made for possible future tree plantings.

As indicated previously, trees seem to affect moderately reactive clays more than extremely reactive clays and so it is recommended that the footing be designed one class higher, ie M designed as H and H as E. Trees should not be planted closer than 3 metres as roots could lift the building and also danger from falling debris is high. Footings should be designed to the requirements of AS2870.

An alternative to the above is to design the footings for the actual site classification and to minimise the effects of trees, especially if the trees are existing, by adopting one or both of the following methods:

a) **Cut off trenches** (Figure 1) to below tree root level. The trench would normally be placed at the edge of the canopy to minimise tree root damage.

The cut off trench would be maximum of 3 metres deep and of mass concrete or sheet piling.

b) **Absorption trenches/piers** (Figure 1) filled with free draining materials and surface drainage directed to these areas, to encourage root growth away from buildings. During times of drought watering should be directed into these areas. Also, if desired, water from sinks (not toilets) could be fed to these trenches.

It must be emphasised that even with the above allowances in the design, some minor and perhaps moderate damage, particularly cracking of brickwork, may be expected if trees are planted near buildings. Obviously it is preferable to avoid such planting.

METHODS OF MINIMISING THE EFFECTS OF TREES ON EXISTING BUILDINGS

The following methods can be employed to minimise the effects of trees on existing buildings. The methods are not necessary complete in themselves and combinations may be required to get the desired result.

For Existing Trees Near Existing Building

1. Remove trees – expansion of soils will occur and some time will elapse before the soil will be in equilibrium and the building can be repaired. Note that full grown trees, close to an old building that shows settlement cracks, have probably reached a practical equilibrium with the foundations and the wisest course is to repair the cracks rather than disturb this equilibrium by removing the trees.

2. Construct cut off trenches as discussed earlier to isolate the building from the tree roots. Again some time will elapse before soil will be in equilibrium and the building can be repaired.

3. Construct absorption trenches/piers filled with free drainage materials as also discussed earlier. This method is generally used in conjunction with a cut off trench.

4. Underpin building to stop further footing settlement. It should be noted that localised underpinning is not generally successful as the building will be founded on different levels and soil strata and so is subject to differential movements. Also, if the tree dies, swelling of the soils would become a problem. Cost is normally also prohibitive.

5. Articulate the building by installing movement joints in brittle materials to allow for movement.

For New Trees near Existing Buildings

1. Plant tress no closer than 1½ h for Classes E sites, 1 h for Class H sites and 3/4 h for Class M sites. If this is not practical then the following:

2. Construct cut off trenches as dicussed earlier.

3. Construct absorption trenches/piers as discussed earlier.

4. Underpin building prior to planting trees.

5. Articulate the building prior to planting trees.

CASE STUDY OF BUILDING DAMAGED BY TREES

An interesting recent case study follows of an investigation carried out by Public Works into the general cracking of the buildings in an educational institution in Sydney's outer west. The site is classified as moderately to highly reactive.

One of the buildings (Figure 2), a workshop, was of portal frame construction with concrete block infill external walls. The portals were supported on piers taken to rock but the slab was allowed to float with the external walls supported on the slab edge thickening. Internal walls were of concrete brick supported off the slab. Construction of the building was completed in 1983.

Building Defects

When the building was inspected in July 1990 only minor cracking was noted in the walls at the north west corner (Photo 1). In March the following year the building was again inspected as cracking had significantly increased. This inspection found that the cracks in the north west corner had opened to about 30mm in June 1991 (Photo 2) and that external and internal walls were showing great distress.

A clump of eucalyptus trees (Photo 3) was found to be growing some 2 to 6 metres away from the corner of the building. The tallest was some 10 metres in height. The trees were identified as a possible cause of cracking but other potential causes such as cracked pipes and/or poorly compacted foundations had to be also investigated.

The pipes were checked and found to be satisfactory and a geotechnical investigation found the building to be on natural ground and that tree roots were going under the building. Investigations indicated that the trees were planted about 1985 and that growing conditions have generally been good so the trees grew quickly with the availability of moisture, but are yet to attain maturity. Because of the good conditions moisture variations in the foundations were minimal. The conditions since July 1990 were exceedingly dry and so the tree roots have removed moisture from the foundations and caused shrinkage. This resulted in settlement of the slab and cracking of the walls.

Remedial Work

Various remedial options were considered, though a cut off trench was not considered because of the closeness of the trees to the building and the nearby sewer main. The normal option would be to remove the trees and wait for foundations to moisten and stabilise. But in this case the client was not willing to wait months or even years for the walls to be repaired and so the following innovative remedial works were recommended (and are awaiting client approval):

a) Remove trees.

b) Underpin north west area of the building using small diameter grout injected mini piles at close centres under the slab (Figure 3).

c) Jack up building to level using grout filled bags (the gap formed underneath will allow for expansion of the foundations).

d) Repair walls and make good slab.

CONCLUSION

In summary, new buildings in reactive clays should be designed to allow for the effect of trees, as planting distance requirements are often impractical in the urban environment. For existing buildings, short of underpinning the whole building, which is generally prohibitive because of cost, the most practical solution is to try to minimise the effects of trees on the building to an acceptable level by using the methods previously indicated.

ACKNOWLEDGEMENT

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SECTION
CUT OFF TRENCH & ABSORPTION PIER/TRENCH DETAILS

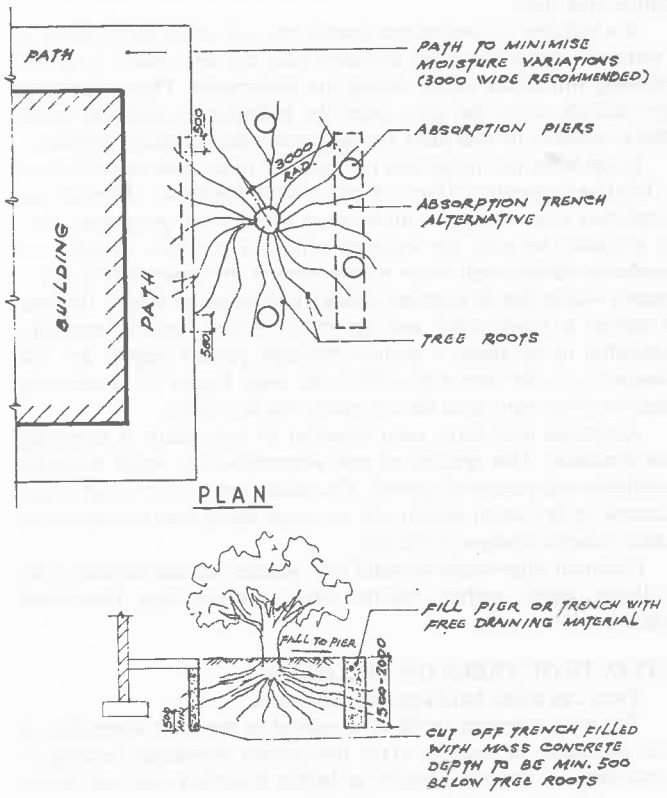


FIGURE 1

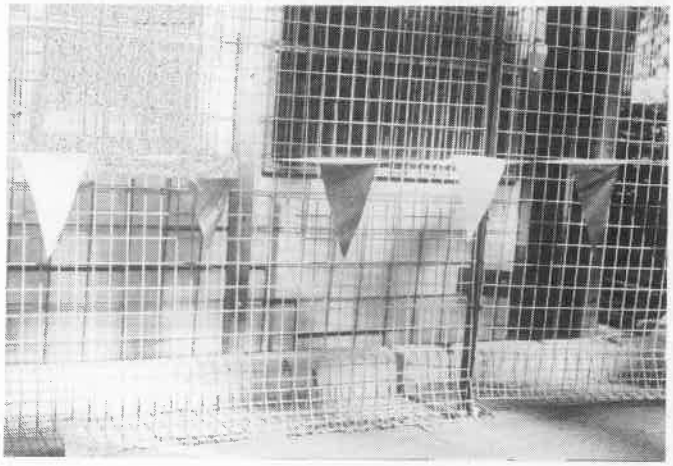
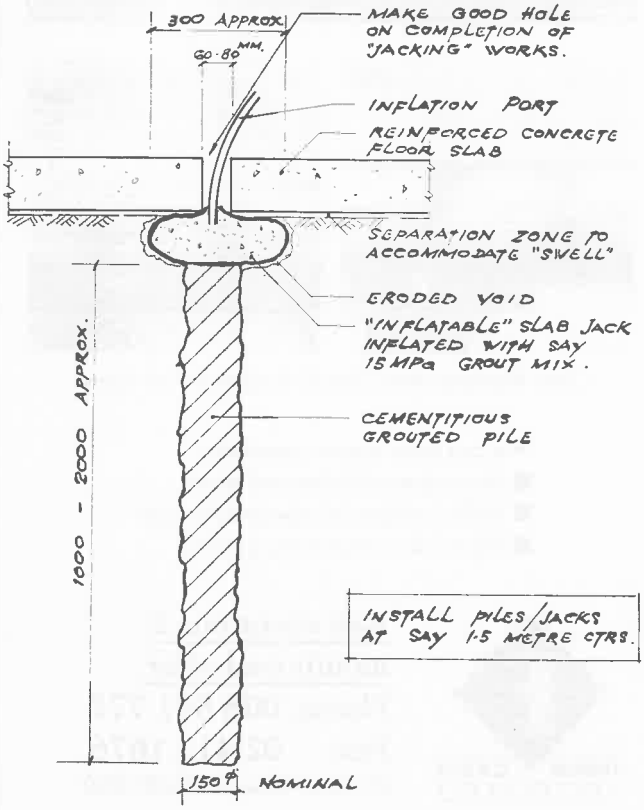


FIGURE 2 – CASE STUDY



UNDERPINNING/SLAB JACKING PROPOSAL
FIGURE 3 – CASE STUDY