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BS5837:2012 Construction Planning survey of the trees at Cheshunt F. C., Theobalds Lane, Cheshunt, Herts, EN8 8RU

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Client: Mr Dean Williamson, LW Developments Ltd., Regency House, White Stubbs Farm, White Stubbs Lane, Broxbourne, Herts. EN10 7QA.

Instruction: The client requires a tree survey at Cheshunt F. C., Theobalds Lane, Cheshunt, Herts, EN8 8RU according to BS5837:2012 for the purposes of construction planning.

Regulatory framework: HSE SIM 01/2007/05 (HSE, 2007), Common sense risk management of trees (Forestry Commission, 2011) and BS5837:2012 (BSI, 2012)

Techniques: Visual Tree Assessment (VTA; Lonsdale, 1999), desk-based enquiries (TPO / CA status, geological survey, mapping).

Limitations: 1. The contents are intended for the sole use of the client. It is also understood that the document will be shared with his architects, the local planning authority and other professionals connected with the proposed development. No liability is accepted for their use by any other parties to advance an argument or claim (including legal or financial) without prior consent. 2. No liability is accepted for defects hidden from view by soil, vegetation or other obstacles to access. 3. Formal assessment of topography, drainage, service conduits, & soil conditions have not been made and are beyond the scope of this report. 4. Specific laboratory investigations of soil properties (plasticity index, moisture content, soil suction pressure) have not been made and are beyond the scope of this report. 5. This report considers only the potential for the trees to influence the proposed development as described in the site layout plans provided by the client, and / or to cause damage or injury under normally expected weather conditions within the limits of the instruction. No liability for damage arising from any other source or mechanism is accepted. 6. This report will be deemed to be invalid if a history of vegetation related subsidence damage in this or surrounding properties exists but has not been made known to the surveyor. 7. This report considers risk mitigation measures, as opposed to risk elimination. Thus, if any given tree is retained, a level of risk will remain. 8. It is understood that any risks associated with these limitations are accepted by the clients.

Weather conditions: Sunny, wind force 1. **Access conditions:** Access was generally unhindered. **Background information:** Site plans cannot be scaled to provide meaningful information within the limits of this report document. Plans have therefore been supplied separately in dwg and pdf formats.

Validity: Plants are biological organisms & change with time. Assessment remains valid for 12 months from the date of inspection, or until a major storm (Wind Force 6 +) is experienced.

Situation: Cheshunt F.C. stands on a level site at an elevation of 25-30m on the south western edge of Cheshunt. Urban development extends south from Cheshunt to Waltham Cross along the valley of the R. Lea to the east (elevation 20-25m). The New River flows from the north to the south at an elevation of around 30m some 500m to the west. Further to the west, ground rises to a series of low undulating hills reaching 87m some 3km away (OS Maps, 2016). Surface deposits consist of approximately 3.5-4m of Kempton Park Gravels over London clay under thin and variable top soils / made ground (BGS, 2016; borehole TL/SE30/15). Winds are generally moderate in this region but likely to be turbulent around buildings. Soils are described as freely draining acid loams of low fertility (LandIS, 2016) suggesting that tree growth may be somewhat inhibited with species not always achieving their full growth potential except where water is freely available.

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BS5837:2012 Tree survey & recommendations

Date:	07/06/2016	Site:	Cheshunt FC, Theobalds Lane, Cheshunt, Herts, EN8 8RU	Conditions:	Sunny, light winds
Client:	LW Developments Ltd c/o Dean Williamson, Regency House, White Stubbs Farm, White Stubbs Lane, Broxbourne, Herts. EN10 7QA			Surveyor:	R J Wilson

Assessment

Ref. No.	Tree Species	Scientific name	Age class	Height (m)	Number of stems	Stem diameter or equivalent (mm)	Crown spread (m) N, E, S, W	Clearance over ground (m)	Health	Structure	Estimated remaining contribution (yrs)	Retention category	Initial recommendations
1	Common ash	Fraxinus excelsior	EM	10		186	4,4,4,3	3	Good (at risk from Ash dieback)	Good	<10	B2	
2	Sycamore	Acer pseudoplatanus	EM	8	5	201	4,3,4,2	0	Good	Good	40+	B2	
3	Hybrid elm	Ulmus x diversifolia	M	10	2	240	2,3,1,4	0	Fair - dense ivy	Fair	10-20	A2	
4	Hybrid elm	Ulmus x diversifolia	M	11		220	1,3,2,5	0	Fair - dense ivy	Fair	10-20	A2	
5	Hybrid elm	Ulmus x diversifolia	M	13	4	400	4,4,5,2	0	Fair - dense ivy	Fair	10-20	A2	
6	Hybrid elm	Ulmus x diversifolia	M	12		320	1,2,2,3	0	Fair - dense ivy	Fair	10-20	A2	
7	Hybrid elm	Ulmus x diversifolia	Dead	12					Dead		Nil	U	Fell
8	Sycamore	Acer pseudoplatanus	M	15.5		600	6,5,8,6	0	Fair - dense ivy	Fair - significant deadwood	40+	B2	Remove deadwood
9	Sycamore	Acer pseudoplatanus	M	13	2	300	1,2,3,4	5	Obscured - dense ivy	Obscured	Unknown	B2	
10	Common ash	Fraxinus excelsior	M	12	3	225	0,4,3,4	5	Good (at risk from Ash dieback); dense ivy;.	Fair - wide spreading stems; dead elm adjacent; significant deadwood	<10	U	Fell
11	Sycamore	Acer pseudoplatanus	M	12	3	274	4,4,5,4	1.5	Good - dense ivy	Fair - overstood coppice	40+	B2	Lift crown to 2.5m over footpath & 5.2m over road. Sever ivy
12	Sycamore	Acer pseudoplatanus	M	16.5	2	634	7,7,7,7	1	Good	Fair - included bark union	40+	B2	Reduce crown by 30%. Lift crown to 2.5m over footpath, 5.2m over road and prune away from overhead wire (0.5m clearance). Sever ivy
13	Sycamore	Acer pseudoplatanus	Dead	17					Dead	Fair - fragile deadwood	Nil	U	Fell
14	Hybrid elm	Ulmus x diversifolia	EM	8		140	1,6,2,0	3	Fair - dense ivy	Fair - unbalanced	10-20	A2	
15	Sycamore	Acer pseudoplatanus	M	12		400	5,6,5,4	4	Good - dense ivy	Fair	40+	B2	
16	Sycamore	Acer pseudoplatanus	M	16		650	7,7,7,6,	4	Good - dense ivy	Fair - included bark union	40+	B2	Reduce crown by 30%; sever ivy
17	Hazel	Coryls avellana	M	8	5	315	6,6,5,4	1.5	Good	Good	40+	B2	Thin
18	Sycamore	Acer pseudoplatanus	M	12		400	5,6,6,7	1	Good - dense ivy	Good	40+	B2	
G1	Hybrid elm, ash, sycamore		EM	7		110 (av)	-,3,-,3	0	Fair - elms dieing from Dutch elm disease	Fair - manage with hedge trimming	Ash, elm <10; Syc 40+	C2	Fell dead elms, manage with hedge trimming
G2	Hybrid elm, ash, sycamore		EM	6		90 (av)	-,2,-,2	0	Fair - at risk from Ash dieback & Dtch elm disease	Fair	<10	C2	Fell dead elms, manage with hedge trimming
G3	Hybrid elm	Ulmus x diversifolia	Dead	5					Dead		Nil	U	Fell

WILSON TREE SURVEYS

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BS5837:2012 Tree survey & recommendations

Date:	07/06/2016	Site:	Cheshunt FC, Theobalds Lane, Cheshunt, Herts, EN8 8RU	Conditions:	Sunny, light winds
Client:	LW Developments Ltd c/o Dean Williamson, Regency House, White Stubbs Farm, White Stubbs Lane, Broxbourne, Herts. EN10 7QA			Surveyor:	R J Wilson

Assessment

Ref. No.	Tree Species	Scientific name	Age class	Height (m)	Number of stems	Stem diameter or equivalent (mm)	Crown spread (m) N, E, S, W	Clearance over ground (m)	Health	Structure	Estimated remaining contribution (yrs)	Retention category	Initial recommendations
G4	Common lime	Tilia x europaea	M	16.5		335	4,6,7,7	0	Good	Fair - significant deadwood	40+	A2	Remove deadwood
G5	Sycamore	Acer pseudoplatanus	M	13	5	426	3,4,4,5	0	Good - dense ivy	Fair	40+	B2	Thin group by 30%
W1	Ash & sycamore woodland with occaisional lime & robinia; understorey of hawthorn, elm, elder & buddleia		M	18		575 (av)	6 (av)	5	Fair - ivy managed, significant deadwood, occaisional dead trees,	Fair but some significant defects noted. Robinia with major Included Bark Union; hollow boughs and trees adjacent to path.	40+	A2	Fell Robinia, remove hollow limb near path. Carry out full safety & condition survey
W2	Sycamore woodland.; nderstorey of occaisional holly & plum		M	18		450 (av)	6 (av)	5	Fair - unmanaged ivy,	Fair	40+	A2	Full safety & condition survey

Tree Numbering:

Trees identified by individual tags are listed according to their tag numbers

Trees not tagged are prefixed with the letter 'N'

New plantings (less than five years in situ) are prefixed with the letter 'P'

Tree age classes:

Sg - sapling

J - juvenile

EM - early mature

M - mature

OM - over mature

St - Senescent

BS5837 tree retention category:

A - High quality trees with a life expectancy of >40 years

B - Trees of moderate quality with a life expectancy of >20 years

C - Trees of low quality with a life expectancy of >10 years OR trees with a stem diameter below 150mm

U - Trees with a life expectancy of <10 years under the current system of land use.

1 - mainly arboricultural qualities

2 - mainly landscape qualities

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Arboricultural Implications Assessment:

- Trees to remove:
  - The following trees have been assessed as Category 'U' (retention for >10 years not realistic) and should be felled:
    - T7, Elm species, dead
    - G3, Elm species, dead
    - T13, sycamore, dead.
  - Retention of the following trees is incompatible with the proposed development and should be removed:
    - T14, Elm species, unbalanced with low crown over proposed access route, at risk from Dutch Elm Disease.
    - T16, Sycamore, standing on location of proposed roundabout.
    - T18, Sycamore, standing immediately adjacent to parking area and units at southeast corner of development.
    - Area of W1, mixed species woodland, standing on location of proposed access route and parking bay (c. 355m^2 equivalent to 14% of area).
    - Area of W2, mixed species woodland, standing on location of proposed access route and parking bay (c. 63m2 equivalent to 4% of area).
- Trees to retain: all other trees may be retained.
- Access facilitation pruning is required to several trees as follows:
  - T1, Ash, lift crown to 5m.
  - G1, mixed species hedge, lift crown at southern end to 3m.
  - T8 Sycamore, lift crown to 3m.
  - T12, 15 & G5 Sycamore, lift crown to 5m.
- AIA plan based on site drawing 15_238_P_SITE received from Mr Williamson by e-mail on 15/07/2016 and overlayed on topographical survey S15-230-100 received by e-mail on 06/06/2016.
- Plan key: Green: Category A trees; Blue – Category B trees; Grey – Category C trees; Red – Category U trees.
  Labels show tree number, retention category, species and height in metres.

Tree Constraints Plan:

- Examination of the root protection areas and crown spreads of surveyed trees in relation to the proposed building layout suggests that trees T1, 8 & 12, G5, W1 & W2 are implicated.
- Shade arcs are not relevant to the proposed development and are not shown.
- Root protection areas are indicated on the Tree Constraints Plan and are drawn in black.
- Root Protection Area (RPA) encroachment:
  - The proposed design would redevelop an existing encroachment by 30% into the RPA of Ash T1 - acceptable with monitoring and careful preservation of roots.
  - The proposed design would result in new permanent encroachment into the RPA of retained trees as follows:
    - T8, Sycamore, 10% encroachment into RPA – within acceptable limits.
    - T12, Sycamore, 6% encroachment into RPA assuming current footpath surface not disturbed – within acceptable limits.
    - G5, Sycamore, 25% encroachment into RPA of most northerly tree in group – acceptable provided mitigation measures employed (see below).

- W1, retained elements of mixed species woodland. Encroachment cannot be calculated precisely however, up to an estimated 33% of the RPA of individual trees could occur in the vicinity of the parking bays – acceptable provided the bays are of no-dig construction.
- W2, retained elements of mixed species woodland. Encroachment cannot be calculated precisely however, up to an estimated 19% of the RPA of individual trees could occur – within acceptable limits.

- Leaf litter, seasonal nuisance, drying conditions.

  Retained trees and hedges do not present any particular difficulties.

- Design constraints.

  Services should be laid in trenches positioned outside RPAs to minimise root damage; soakaways etc. to be positioned outside RPAs.

  Most hard surfaces may be of any suitable construction to provide a non-slip surface.

  Parking bays adjacent to W1 are to be of 'no-dig' construction to avoid unacceptable damage to the roots of retained trees.

  Redevelopment of the area around T1 to proceed carefully avoiding damage to tree roots, under the supervision of an arboriculturists. Gateway apron may require a 'no-dig' approach if significant roots found under existing surfaces.

  Tree protection barriers to be used to protect trees and RPAs as per BS5837:2012.

  Vehicles, building materials, waste piles / skips, and building activities are to be excluded from the Construction Exclusion Zones.

- Pre- and post-construction mitigation.

  The unpaved portion of the RPA of G5 should be decompacted post-construction using Terravent or similar compressed-gas decompaction techniques.

  The site layout plan suggests that extensive landscaping and tree planting is an integral part of the design. However, the loss of woodland area to the south of the site could be offset by the planting of a similar or greater area of mixed species woodland adjacent to the eastern boundary of the site. Species could be selected to improve the ecological value of the site and provide a source of food and cover for birds.

Tree Protection Plan:

- Tree protection barriers and areas of ground protection have been drawn on the TPP. In places, the barrier could be constructed so as to be contiguous with site perimeter fencing.
- Plan key: Tree Protection Barriers shown in magenta; areas of ground protection and of 'no-dig' construction drawn in black diagonal shading.
- Areas enclosed by barriers or lying to the outside of the barriers (with respect to the development site) are 'Construction Exclusion Zones'.
- Tree protection barriers should be constructed as detailed in BS5837:2012 clause 6.2 as described and illustrated below:
  - "6.2.2.1 Barriers should be fit for the purpose of excluding construction activity and appropriate to the degree and proximity of work taking place around the retained tree(s). Barriers should be maintained to ensure that they remain rigid and complete.
  - 6.2.2.2 The default specification should consist of a vertical and horizontal scaffold framework, well-braced to resist impacts, as illustrated in Figure 2. The vertical tubes should be spaced at a maximum interval of 3m and driven securely into the ground. Onto this framework, welded mesh panels should be securely fixed. Care should be exercised when locating the vertical poles to avoid underground services and, in the case of bracing poles, also to avoid contact with structural roots. If the presence of underground services precludes the use of driven poles, an alternative specification should be prepared in conjunction with the project arboriculturists that provides an equal level of protection. Such alternatives could include the attachment of the panels to a free-standing scaffold support framework.

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- 6.2.2.3 Where the site circumstances and associated risk of damaging incursion into the RPA do not necessitate the default level of protection, an alternative specification should be prepared by the project arboriculturists and, where relevant, agreed with the local planning authority. For example, 2m tall welded mesh panels on rubber or concrete feet might provide an adequate level of protection from cars, vans, pedestrians and manually operated plant. In such cases, the fence panels should be joined together with a minimum of two anti-tamper couplers, installed so that they can only be removed from the inside of the fence. The distance between the fence couplers should be at least 1m and should be uniform throughout the fence. The panels should be supported on the inner side by stabiliser struts, which should normally be attached to a base plate secured with ground pins (Figure 3a). Where the fencing is to be erected on retained hard surfacing or it is otherwise unfeasible to use ground pins, e.g. due to the presence of underground services, the stabiliser struts should be mounted on a block tray (Figure 3b).
- 6.2.2.4 All-weather notices should be attached to the barrier with words such as: "CONSTRUCTION EXCLUSION ZONE – NO ACCESS"."

- Temporary ground protection should be installed to the east of the proposed extension for the duration of the construction project and should conform to BS5837:2012 clause 6.2 as described below:
  - "6.2.3.3 New temporary ground protection should be capable of supporting any traffic entering or using the site without being distorted or causing compaction of underlying soil.
  - NOTE The ground protection might comprise one of the following:
  - For pedestrian movements only, a single thickness of scaffold boards placed either on top of a driven scaffold frame, so as to form a suspended walkway, or on top of a compression-resistant layer (eg. 100mm depth of woodchip or sharp sand), laid onto a geotextile membrane; …"
- Hard surfaces of 'no-dig' construction should be designed according to BS5837:2012 clause 7.4 as follows:

  BS5837:2012 clause 7.4 "Permanent Hard Surfacing within the RPA"

  7.4.2 Design Recommendations
  - 7.4.2.1 The design should not require excavation into the soil, including through lowering of levels and / or scraping, other than the removal, sing hand tools, of any turf layer or other surface vegetation. If it is intended to use the new surface for construction access, it is essential that he extra loading and wear arising from this are taken into account during the design process.
  - 7.4.2.2 The structure of the hard surface should be designed to avoid localised compaction by evenly distributing the loading over the track width and wheelbase of any vehicles expected to use the access.
  - 7.4.2.3 New permanent hard surfacing should not exceed 20% of any existing unsurfaced ground within the RPA.
  - 7.4.2.4 If the new surface is likely to be subject to de-icing salt application, an impermeable barrier should be incorporated to prevent contamination of the rooting area. Run-off should be directed away from the RPA.
  - 7.4.2.5 Where a permeable surface is to be used by vehicular traffic, a geotextile should be used at the base of the construction to help prevent pollution contamination of the rooting area below.
  - 7.4.2.6 Permeable hard surfacing can result in soil volume moisture content remaining at or near field capacity for long periods. Where there is a risk of waterlogging, the design should incorporate appropriate land drainage. Land drainage within the RPA should be designed to avoid damage to the tree and the soil structure, e.g. sand slitting formed by compressed air soil displacement with the slits set radially to the tree.

- 7.4.2.7 The hard surface should be resistant to or tolerant of deformation by tree roots, and should be set back from the stem of the tree and its above-ground root buttressing by a minimum of 500mm to allow for growth and movement. Resulting gaps may be filled using appropriate inert granular material.

  NOTE 1: Appropriate sub-base options for new hard surfacing include three-dimensional cellular confinement systems. Alternatively, piles, pads or elevated beams can be used to support surfaces to bridge over the RPA or, following exploratory investigations to determine location, to provide support within the RPA while allowing retention of roots greater than 25mm diameter.

  NOTE 2: The use of two-dimensional load suspension systems is not recommended for surfaces intended for use by vehicles.
- 7.4.2.8 When designing the hard surface, account should be taken of finished levels in relation to adjacent structures, including damp-proof courses, garage slabs and links to existing vehicular cross-overs.

  NOTE: Attention is drawn to the Building Regulations 2010, the Building (Scotland) Regulations 2004, as amended and the Building Regulations (Northern Ireland) 2000, in respect of the need for accessible thresholds.
- 7.4.2.9 If a permeable surface is to be used by construction traffic, this should be protected with a temporary sacrificial surface laid over a geotextile separator to ensure that its permeability is retained (i.e. interstices should not become blocked during construction).

7.4.3 Edge supports

- The excavation needed for the placement of kerbs, edgings and their associated foundations and haunchings can damage tree roots. Within the RPA, this should be avoided either by the use of alternative methods of edge support or by not using supports at all.
- NOTE: For example, where kerbing is required for light structures, such as footpaths, above-ground peg and board edging might be acceptable. Where areas of hard surface require edge support, the use of sleepers (pinned in place where required), gabions or other non-invasive ground-contact structures, including the use of proprietary products, can provide appropriate solutions.

7.4.4 Precautions

- 7.4.4.1 The soil structure including the area beneath the proposed new hard surface should be protected from compaction during installation. This may be achieved by: a) the use of temporary ground protection in accordance with 6.2.3 to safeguard the working area; b) constructing the new surface from machinery working forward from the surface as it is constructed (known as “rolling out”).
- 7.4.4.2 Where a herbicide is used to control vegetation prior to construction of hard surfacing, the manufacturer’s guidance should be strictly followed and care should be taken to avoid any damaging effects on trees or other vegetation to be retained.

  NOTE: The use of appropriate geotextiles can provide a barrier that inhibits weed growth but allows water and gasses to pass freely.
- 7.4.4.3 The ground should not be skimmed to establish the new hard surface at the former ground level. Loose organic matter and / or turf should be removed carefully using hand tools. The new surface should then be established above the soil.
- 7.4.4.4 Raising levels should be achieved by the use of granular material which remains gas- and water-permeable throughout its design life.
- 7.4.4.5 Due to the highly alkaline leachate produced during the curing of wet concrete, concrete should not be poured within the RPA unless an impermeable liner has been installed.

Further advice may be obtained from Arboricultural Practise Note 12, “Through the Trees to Development”, Arboricultural Advisory and Information Service, 2007 (attached to this report).

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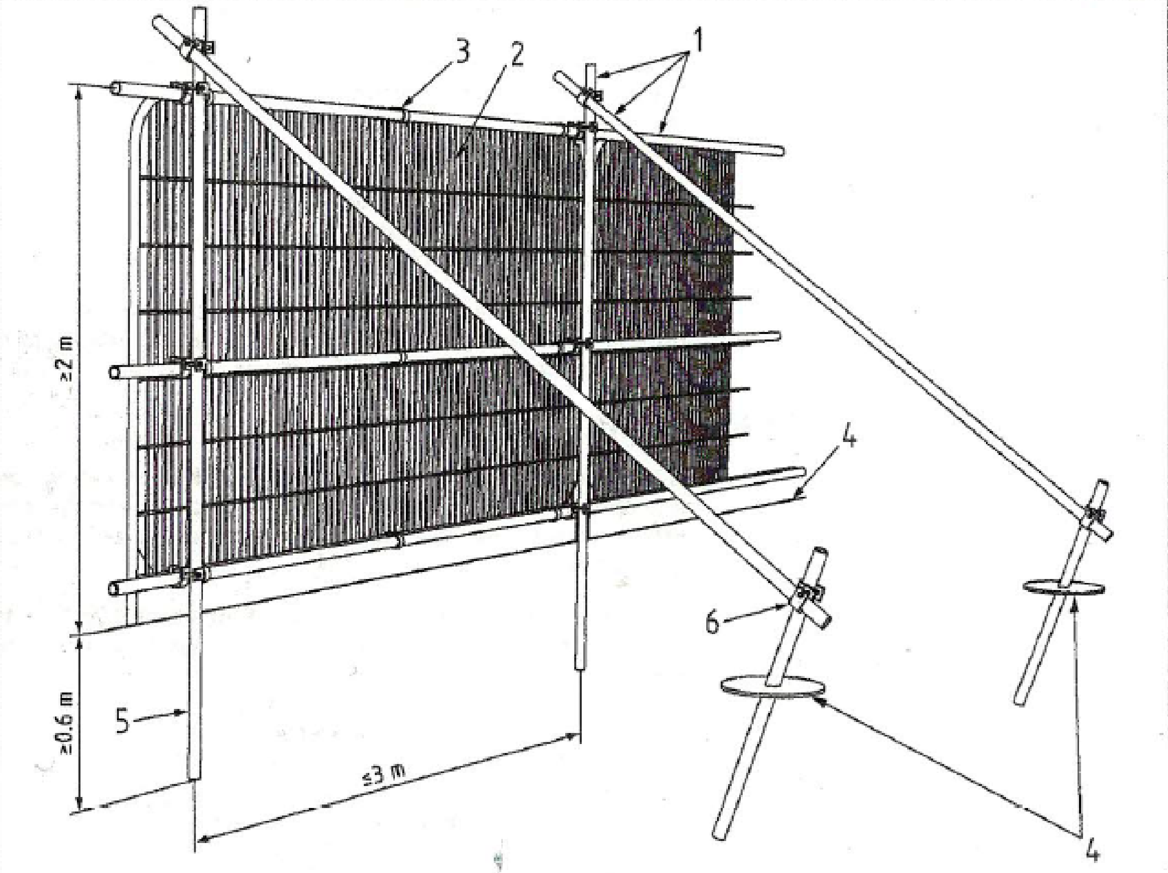
Figure 2 **Default specification for protective barrier**



Key

1 Standard scaffold poles

2 Heavy gauge 2 m tall galvanized tube and welded mesh infill panels

3 Panels secured to uprights and cross-members with wire ties

4 Ground level

5 Uprights driven into the ground until secure (minimum depth 0.6 m)

6 Standard scaffold clamps

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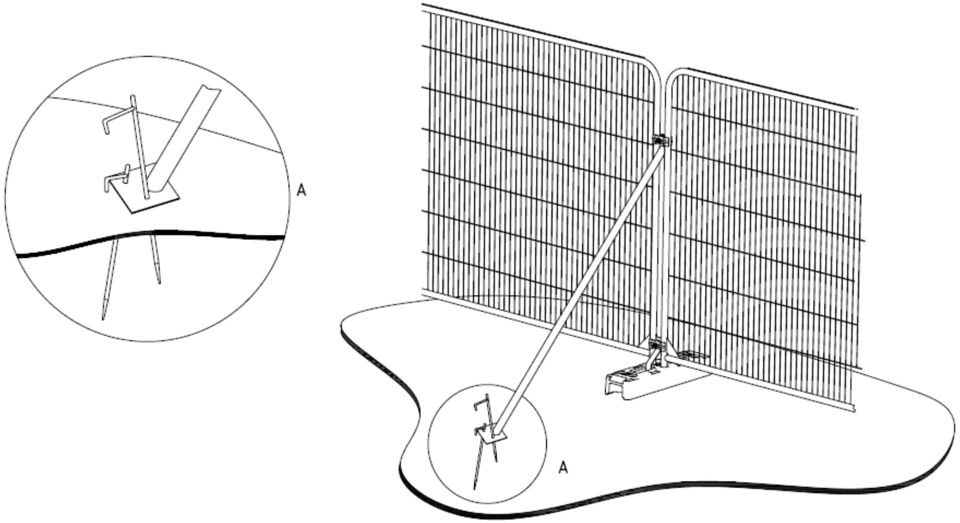
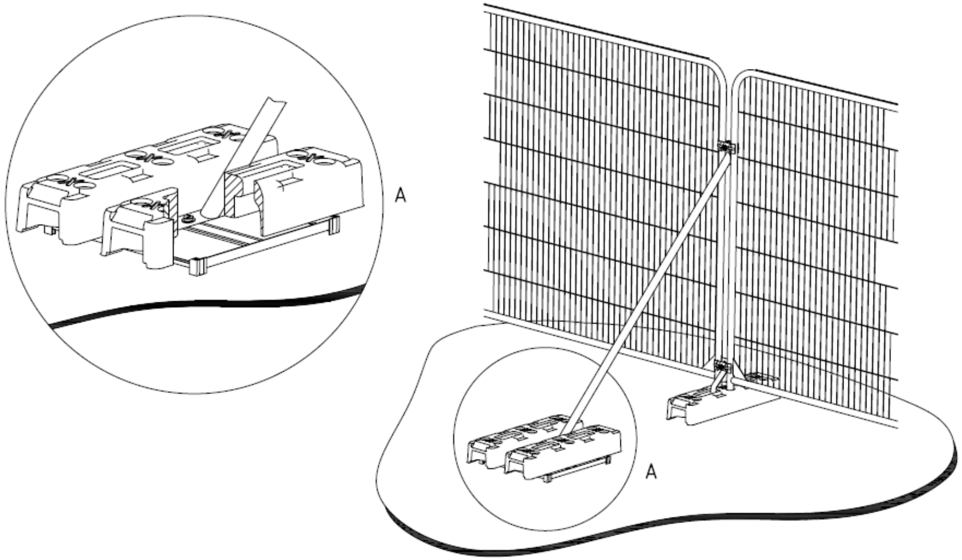
Figure 3 **Examples of above-ground stabilizing systems**



a) Stabilizer strut with base plate secured with ground pins



b) Stabilizer strut mounted on block tray

Trees in focus

APN 12

Arboricultural Practice Notes

Through the Trees to Development

Derek Patch and Ben Holding

Arboricultural Advisory and Information Service

Summary

The majority of tree roots grow in the upper metre of soil and they may spread outwards in any direction a distance equal to the tree's height. Any disturbance of the ground within the root spread of a tree can damage its roots and may severely injure the tree. Damage to roots will interrupt the supply of water necessary to keep the tree alive and may cause decline in vigour, dieback or even death of the tree.The tree may also be made unstable and so pose an unacceptable threat to the safety of people and property. Development of a site, including construction of access routes, driveways and parking areas can result in substantial root severance of trees. Techniques for the construction of access drives, which may avoid or lessen the damage caused to trees, are described.

This note embraces the principles first published by The Tree Advice Trust as "Driveways Close to Trees" (Aboricutural Practice Note No. 1[1]) and reviews where the principles may be applied in practice.

Trees: A Cause of Conflict

Development of a site is sometimes hampered or prevented because of the presence of trees. Local authorities and residents may wish to see trees 'preserved' whilst developers seek permission to build close to them - often ignorant about the damage this may cause to trees. Even developments such as access drives and parking areas can threaten existing nearby trees.

Traditional driveway construction (excavation and backfilling with a compactable load-bearing sub-base material) can seriously damage tree roots. Such damage occurs because of a lack of understanding that roots mainly grow outwards from a tree's trunk, near to the soil surface, rather than downwards (Dobson 1995). Where there is a significant risk of damage to trees by root severance, or changes in soil conditions during construction, local planning authorities may sometimes refuse permission for installation of an access driveway or parking area close to trees - especially if the trees are subjects of Tree Preservation Orders.

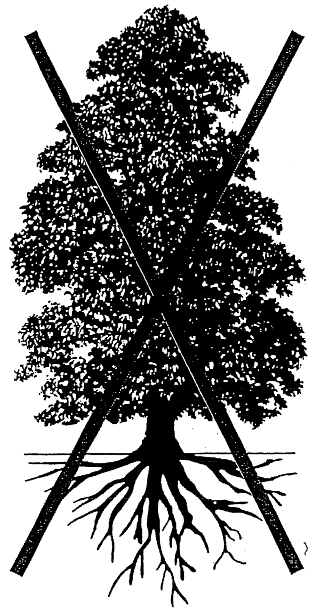


Figure 1.
Incorrect representation of a tree's root system.

However, if the potential for damage to the tree's root system (e.g. by severance or soil compaction) can be avoided during construction, development may be more easily accepted. A technique is described below which should reduce the risk of significant damage to tree roots while enabling access and parking for light vehicles to be constructed close to trees.

Where Do Tree Roots Grow?

Survival of a tree depends on its roots being able to absorb enough water from the soil to sustain the foliage (an estimated 1,000 litres per day in summer for a fully grown forest tree in a rural area) and on developing a strong root system capable of keeping the tree upright through autumn and winter gales. To achieve this the tree's roots must exploit a very large volume of soil. However, the assumption that these requirements are met by a system of roots growing predominantly downwards (Figure 1), and that anchoring roots are very thick and descend into the soil for many metres (like the base of a lamp post) is incorrect. In reality tree roots:

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[1] Driveways Close to Trees, Arboricultural Practice Note No. 1 is withdrawn and superceded by this wider text.

- grow in any direction more or less parallel with the soil surface rather than vertically (Figure 2). This is also true for trees growing on sloping land.
- are usually relatively shallow - most of a tree's roots are in the upper metre of soil.
- usually radiate outwards from a tree for a distance equivalent to at least the tree's height (which for a mature tree may be 20 m or more).
- can be 30 cm or more in diameter at the base of the trunk.
- sub-divide and taper rapidly as they extend out from the trunk.
- are only 2-3 cm in diameter, and often much less at 3-4 m distance from the trunk.

The small woody roots (those less than 3 cm diameter) taper very little but they may spread out for long distances. Smaller, non-woody roots (sometimes described as white, feeder, fibrous, fragile or absorbing roots) grow outwards and usually upwards from the woody roots and subdivide to exploit the better aerated surface soil. Although generally short lived they (and the fungi associated with them - called mycorrizas) are the principal absorbers of moisture and nutrients.

Most roots (both thick and fine) are situated close to the soil surface, forming a thin layer less than 1m deep, but some small roots (usually only a few mm in diameter) may reach 2 m or more deep.

Roots and the Soil

Roots are living and, like all plants and animals, must have oxygen if they are to survive. Without oxygen roots are unable to function properly or grow, and when they are starved of oxygen for prolonged periods, they die.

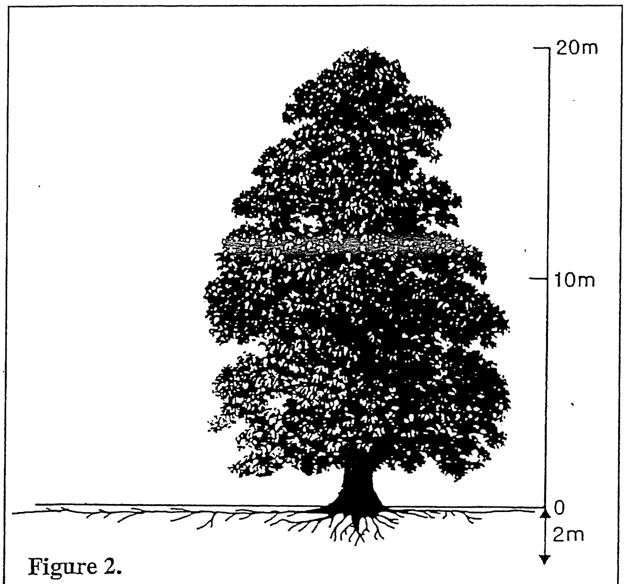


Figure 2.
Trees have a relatively shallow but wide spreading root system.

Both oxygen and water are held in the pores between the soil particles. Where the pores are large (e.g. in coarse or sandy soils) the soil will generally be freely draining and well-aerated, but where the pores are small (e.g. in heavy clays or soils which have been compacted) they may be full of water and have a poor supply of oxygen.

Most trees that have been growing undisturbed on a site for many years will have developed an extensive root system with the roots growing where the soil conditions are most favourable. There will be a balance between the development of the crown (which demands water) and the roots (which supply it). Any sudden alteration of the soil conditions within the tree's rooting area (a circle of radius equal to the tree's height) will therefore upset this balance. For example, the single passage of a machine will 'squeeze' the soil closing up the pores (causing compaction - especially in the upper levels) and so reduce the amount of oxygen available to roots which prevents them from growing through the soil. With each additional machinery movement the compaction increases and so do the problems for the tree and its roots.

Placing soil or other materials over the root system of a tree will impede air movement into and out of the soil around the roots and consequently reduce the availability of oxygen to the roots. The effect on the tree is usually progressive shoot and branch dieback until a new balance has been reached between the reduced capacity of the damaged root system to absorb water and the demands of the leaves. If damage is progressive or so severe that such a balance cannot be achieved, the tree will ultimately die.

Excavations - **even stripping the topsoil** - within the rooting area will sever roots. The closer the excavation is to the trunk of the tree the larger will be the roots lost and the greater the significance for the health and stability of the tree. Once the excavation is a metre deep virtually all of the roots growing into the excavated area will have been severed. The tree may then either be unable to absorb sufficient water to sustain the foliage and dieback will occur, or anchorage will be so reduced that the tree is unsafe and has to be severely pruned or even felled for safety.

Soil compaction, excavations and soil level increases will all damage roots and the closer to the trunk they occur the greater the damage inflicted on the tree. Nevertheless, healthy trees are generally able to withstand the loss of some roots (a maximum of about 20% of the rooting area, Helliwell and Fordham (1992)) without noticeable adverse effects.

Development Near Trees

British Standard BS 5837:2005 *Trees in Relation to Construction – Recommendations* recommends that on construction sites an area around a tree should be left undisturbed (the Root Protection Area) so that unacceptable damage to the root system is avoided. In the British Standard the Root Protection Area is calculated as the equivalent of a circle about 12x the diameter of the tree's trunk (measured at 1.5m above ground level). The distance from the trunk extending to the branch spread, or half the tree's height, whichever is the greater (Figure 3) is a useful indicator of the typical Root Protection Area for a given tree.

The Root Protection Area is an area of protected ground around a tree within which any activity that could damage roots should be prohibited without the prior agreement of an aboriculturist.

However, if the principles and guidelines set out below are followed, installation of access driveways and parking for light vehicles within the Root Protection Area may, in many situations, be possible without causing significant, permanent damage to trees. Nevertheless, expert arboricultural advice should be sought to determine whether the tree and the site conditions lend themselves to the principles described in this Note. Any assessment of a site should include consideration of the health and overall condition of the tree(s). That is because old and declining trees may be vulnerable to sudden changes in the site conditions and so they may warrant a larger area than the minimum recommended in the British Standard.

Engineering Needs

Driveways, footpaths and car parking areas must be built on a firm, stable base. Engineers usually achieve this by excavating the soil to a depth of about 0.5 m, compacting the base if necessary, and backfilling with an inert material that can be compacted to form a stable platform. This usually involves progressive placement of layers of inert material with each being compacted by repeated passes of a powered roller or whacker plate. Each pass of a machine creates increasing compaction at depth in the soil. The edges of the excavation act as the supporting formation and kerbs or other edgings may be used to retain the surface material.

Any such excavations or soil stripping will sever roots and should be avoided within the Root Protection Area.

Compacting the base of an excavation can change the bulk density of the subsoil creating conditions unsuitable for the survival of any roots, particularly the water absorbing fine roots, contained in that volume. Placement and particularly compaction of load bearing construction materials will contribute to this creation of conditions unsuitable for root survival

On many sites it is possible to construct an adequately supported access driveway suitable for limited usage by light vehicles while retaining healthy, stable trees, by adoption of three principals particularly when construction is within the Root Protection Area as determined in consultation with an arboriculturist.

Where the finished structure will be adopted by the Highway Authority a more robust specification may be required. Provided the same principles are embraced construction across the root systems of trees should still be feasible.

Protection and Construction

For tree roots to be retained undamaged there must be *no excavation, no soil stripping* and *no grading of the site within the Root Protection Area* - in other words, **NO DIGGING**. This means that construction will have to be above the existing ground level.

Passage of vehicles across an unprotected soil surface must also be avoided, particularly where the soil is wet, as this will cause breakage of surface roots, soil compaction and consequently reduced soil aeration. These problems are heightened on clay soils. Most vulnerable to soil compaction are the fine white roots (those roots that are generally difficult to find when soil is examined) essential for water absorption. Surviving roots may not be able to grow through the compacted soil.

To reiterate there must be **NO COMPACTION** of the soil.

Where trees are to be retained on a site it is essential, therefore, that all but the immediate area of the development is protected from access and construction operations by fencing as recommended in BS 5837.

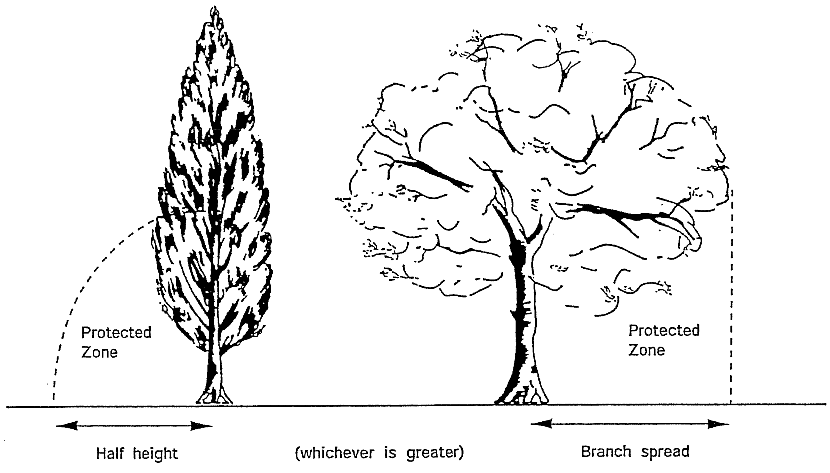


Figure 3.
Distance from a tree which constitutes the zone in which roots should be protected - i.e. no digging.

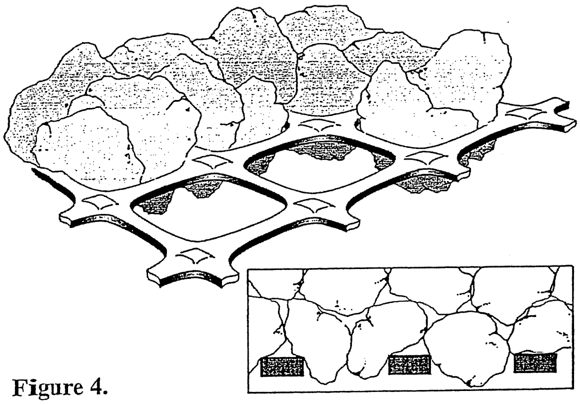


Figure 4.
The mechanism of interlock between aggregate and geogrid.

No-Dig Construction

Successful retention of trees, even when adopting a no-dig method, depends upon the condition (health and vigour) of the tree(s), which should be assessed by a qualified arboriculturist, and on adherence to three simple rules within the Root Protection Area:

- roots must not be severed, cut or broken – **no digging**
- ground levels must not be changed - **no digging, no soil level raising**
- **soil must not be compacted – no tracking of vehicles**
- oxygen must be able to diffuse into the soil beneath the engineered surface – **no tracking of vehicles**

Meeting the Engineering Needs

Damage to trees can be avoided only if the construction embraces the above simple principles and, within the fenced Root Protection Area, is no more than 5m wide.

Construction should incorporate two main components:

- a synthetic load spreading material
- a no-fines aggregate sub-base

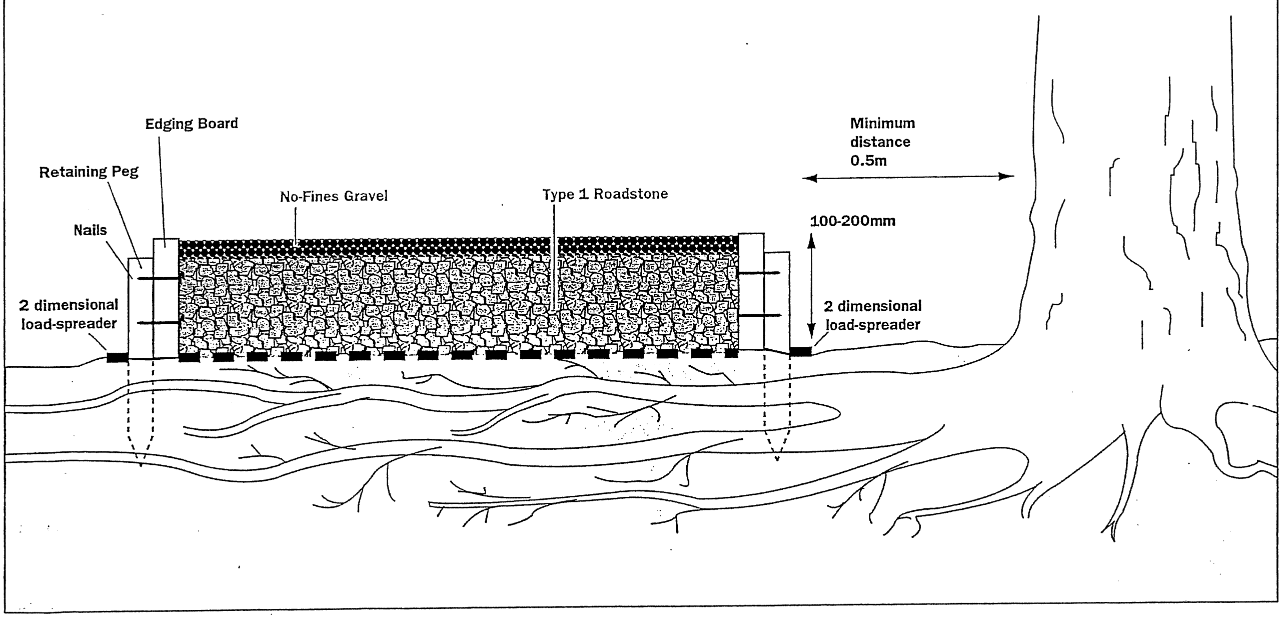
Note: a geotextile, which is usually used to prevent layers of different mineral materials mixing while allowing water to pass through, is not designed to be load bearing.

'Load spreading' materials, are synthetic grids/webs designed to support roads on soft ground by distributing the load of a wheel over a larger area than would normally occur. They may be 2- or 3-dimensional.

When placed on a 2-dimensional grid, appropriate, no-fines granular sub-base material penetrates the mesh, but is unable to pass through it, forming a positive interlock (Figure 4). This interlock between aggregate and grid provides a reinforced platform and efficient load spread into the underlying ground over a wider area than the footprint of the wheel on the surface. A suitable geogrid/aggregate combination constructed with the grid under tension should prevent rutting of the ground beneath the construction (Figure 5).

The 3-dimensional load spreading products (Cellular Confinement System) create cells into which the sub-base material is placed (Figure 6). Such a construction does not support the sub-base material, it confines the material in discrete cells. Manufacturers recommended, therefore, that a geotextile (see note above) is placed between the ground

Figure 5. Diagram of a 'no-dig' method for constructing access drives and parking near to trees in order to minimise damage to tree roots. *(Not to scale)*



and the load spreader to prevent the cell-contained mineral material being pressed down into the underlying soil.

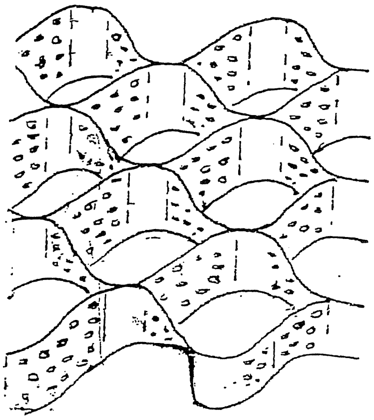


Figure 6.
3-dimensional load-spreader

A no-dig construction, that is a construction above ground level, will need to be contained to prevent outward creep under the weight of vehicles. This may be achieved with an edging support provided its construction does not involve excavation. A suitable material may be long-life timbers pinned through the load-spreader into the underlying soil. This could add strength to the structure because the pressure of vehicles forcing the sub-base downwards and outwards will tend to increase the tension on the grid and any tendency to rutting.

Note: some manufacturers specify that their product should be placed in a 100mm or greater depth of formation (i.e. excavation). It is important that before such a construction is adopted the agreement of an arboriculturist who has considered the circumstances of the tree's health and evaluated the site conditions, should be obtained. Failure to do so could result in breach of a Tree Preservation Order and Conservation Area legislation because roots will inevitably be damaged by an excavation of as little as 100mm.

The granular sub-base material should have a no 'fines' content which means that even when it is compacted it should be freely draining and will allow oxygen to diffuse into, and damaging gases (e.g. carbon dioxide and methane) out of the soil.

For site-specific prescriptions and materials specifications advice should be sought from a qualified geotechnical or civil engineer who should work in consultation with an arboriculturist.

Putting the Principles into Practice

Is the site suitable for a no-dig construction? (see next section)

Construction should ideally be undertaken in dry weather between May and October when the ground is likely to be driest and least prone to damaging compaction.

There must be a method of working that does not require movement of machinery or heavy plant within the branch spread of the tree before the ground is protected by a load spreader and the sub-base. Then the movements must be only along the construction.

For example when making a new access into a site construction should commence at the entrance to the site and 'roll out' the driveway in front of the machinery which always remains over the sub-base.

Ground vegetation should be killed using a translocated herbicide such as glyphosate[2]. (This may be most appropriately done in consultation with an experienced arboriculturist to ensure that the chemical and application method do not result in damage to retained trees.) After allowing time for the chemical to be absorbed and kill the plants, including their roots, gather up the dead organic material - this will prevent the build up of anaerobic conditions beneath the construction which might otherwise occur as dead vegetation decomposes.

Carefully remove major protrusions such as rocks.

Remove tree or shrub stumps (stumps should be ground out rather than excavated to minimise soil disturbance).

Fill major hollows with clean sharp sand – **DO NOT GRADE-OFF HIGH SPOTS.**

If necessary, for example when using a three dimensional cellular confinement product as a load spreader, a geotextile should be spread over the area of the driveway or car park.

With a two dimensional load spreading product into which the no-fines sub-base stone forms a lock a geotextile may be used but it is not essential.

Lay the synthetic load spreader directly onto the levelled ground or the geotextile as appropriate.

Secure the synthetic load spreader under tension using long pins driven into the ground through the grid.

Note: Before driving pins into the ground check for underground services that could be damaged.

Construct an edging which is secured through the load spreader so that pressure on the running surface will force the edging outwards and so increase the tension on the load spreader.

Cover the load spreader with a minimum of 100 mm of no-fines aggregate. This should not be tipped straight onto the synthetic material, but should be placed at one end and then pushed onto the load spreader between the retaining edges so that machinery is supported by the spread sub-base material rather than directly on the load-spreader and not on the ground either side of it.

Compact the sub-base to ensure binding with the load spreader and to minimise future rutting.

[2] When selecting a herbicide care must be taken to select a product which does not damage the roots of desirable vegetation that may extend into the treated area. Always read the product label before use.

A further geotextile may be placed over the sub-base to prevent dry bedding materials or surfacings merging with the sub-base.

Place the final surface. In the main it is likely that this will consist of gravel or tarmacadam, although paving slabs and brick paviours may be acceptable provided they are dry bedded on the sub-base and the joints are not sealed with grout, to allow for infiltration of water and gaseous diffusion[3].

Where a mass concrete, or impervious surface material is required the specification for an adoptable road (see below) should be used.

Sites are not all the Same!

The principles detailed above, if applied sensibly, should permit access to be constructed across the root system of a healthy tree. That is where the construction passes through the Root Protected Area retained around a tree as recommended by British Standard BS 5837:2005 *Trees in relation to construction - Recommendations.*

Why the 'sensibly'? No two sites are the same, in fact some are totally unsuitable for a no-dig construction and it may be necessary to admit that access to the site cannot be achieved if certain trees are so important/valuable that their retention is essential. For example, where trees grow on an old hedge bank excavation to cut through the bank may be unavoidable and so an unacceptable proportion of the root system would be severed. In contrast ditches that can be filled/piped/bridged (Figure 7) should be less problematic.

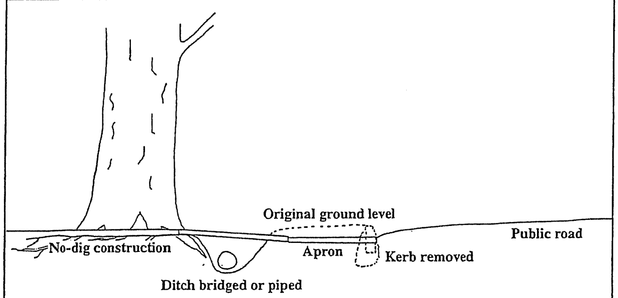


Figure 7. No-dig construction and a ditch.

When planning a driveway it is important to consider the ground levels on site and to relate them to the fixed level on the public thoroughfare into which the drive must connect and be tied. Where a roadside verge within the root protection area around a tree cannot be crossed without excavations then a different access point may be needed if the tree is deemed to be of very significant value to the amenities of the area.

Highway Authorities generally seek an 'apron' (upto 4m long), with a shallow or no gradient and a sealed surface at the entrance to a site where the drive joins the highway. This is to reduce the risk of loose material migrating onto the footpath and road where it could become a hazard. Such an apron may involve excavation thus reducing the scope for a drive constructed using the no-dig principles.

The simplest site on which a no-dig construction can be used is where the ground falls into the site from the edge of the road. Level sites should not pose significant problems provided there is an adequately wide verge/pavement to accommodate the 'apron' without severing roots.

It is also important to remember that the no-dig construction needs to tie onto the road and also the levels of the garage or damp proof course of a building.

The roots of a tree will generally grow parallel with the ground surface – they do not grow preferentially up, down or across the slope! As such trees growing on a slope do not present any problems different from those of trees growing on a flat site – it is the engineering requirements that differ! Where the drive crosses the contours at a gentle angle, there is no reason why the depth of a no-dig construction should be constant across its width of a drive. The engineering problem may be how to retain the structure. The scope for increasing the lift on one side of a drive is not unlimited – probably 1:3 should be a maximum (Figure 8).

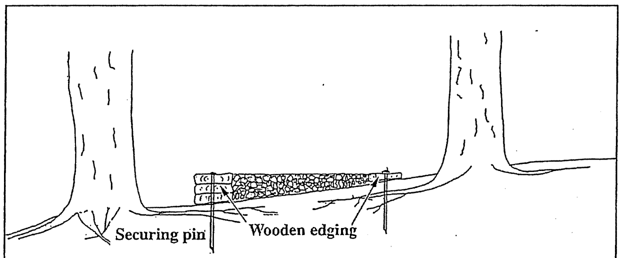


Figure 8. No-dig construction across a slope.

Permanently wet areas of ground should normally be drained, or they may be filled with no-fines stone, or if the water is flowing, they may be partially piped. In contrast, seasonally wet areas may benefit from drainage and building up the ground with coarse stone with a low fines component over which the drive is constructed.

The depth of each layer in the construction of a no-dig drive will be influenced by the bearing capacity of the ground over which the drive will pass. Also there must be consideration of the weight of traffic that will use the drive. The final design should, therefore, be achieved in discussion between a civil engineer and an arboriculturist.

A Potential Benefit

Inclusion of a load spreader in a construction should offer resistance to direct damage often caused to drives and car parks by diameter growth of roots under the structure.

[3] For drives less than 5m wide the finished surface may be constructed of a less permeable material such as asphalt/or reinforced mass concrete.

Adoptable Highways

The above construction is generally unacceptable where the finished structure is to be adopted by a Highway Authority - a more robust specification will be required for example pre-rutting, that is compaction of the ground under the driveway before construction commences, will be required. Such an engineering requirement will usually involve a vibrating roller or repeated tracking of heavy machinery, which is totally unacceptable for the welfare of the tree. The repeated tracking needed to deliver and consolidate layers of aggregate is likely to severely compact the underlying soil at increasing depth. A single pass of a vehicle can cause significant changes in the pore structure in the soil. Repeated passes will further compact the soil which will favour the needs of the engineer, but will eventually create conditions in the soil that are totally unsuitable for root activity and root death will result.

In such circumstances consideration must be given to designing and constructing a running surface which does not require either excavation, or direct compaction of the material under the construction and which does not place a dynamic force on the soil around tree roots. Further, an adopted road is likely to have a width greater than the 5m driveway considered above. The wider the construction the greater the impedance to gaseous exchange between the atmosphere and the soil around roots.

Where a load spreader is acceptable to the Highway Authority there will be need for a greater thickness of no-fines sub-base to support the loads carried by the finished structure[4]. It is then practical to include a system of perforated pipes laid in the sub-base material with venting either at the road surface or in the verges at the edge of the road. The finished surface over the sub-base may then be impermeable to gases (e.g. hot rolled asphalt, or concrete). Inclusion of a 'clay board', or similar over the sub-base may be appropriate to aid casting of the surface.

In the more extreme circumstances a construction to bridge the root system of a very high value tree could be based on an elevated 'board walk' or causeway. That is a series of pads sunk into the ground (causing only localised damage to the root system) supporting beams across which reinforced concrete beams are placed (c.f. a suspended floor in a building). Such a construction would not apply pressure to the ground and so there would not be any threat to underlying tree roots. This removes the need for a load spreader and specialized anchors and edgings.

Final Remarks

Adoption of the no-dig principles for creating access and parking for light vehicles near to trees, which avoids root severance, should help to overcome concerns about possible adverse effects on trees. Nevertheless, successful retention of a tree will depend upon the site in relation to the adjacent highway and strict adherence to the above principles, and upon the tree's condition - indicative of its ability to withstand changes in its rooting environment. This should be assessed by a qualified arboriculturist.

On completion a no-dig construction will be at least 300m above the original ground level.

Acknowledgement

The authors acknowledge the valuable comments and suggestions made by colleagues and members of the Arboricultural Association.

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[4] Type 1, as specified by the Highways Agency (2004) is not a recommended aggregate for use around tree roots because it contains a significant proportion of 'fines'.