6. DETAILED INSPECTION, DOCUMENTATION AND PLANNING

The structure has now been cleaned down so that most faults and weaknesses are visible. A good set of measured drawings is available. The time is ripe to carry out a detailed inspection of the structure. The prime purpose of such inspection is to decide which components need stabilising and which components need repair or replacement. Unsound components can be marked on the drawings.

If you are going to seek expert advice on how to best carry out the stabilisation of a structure, then this is by far the best time to obtain it - after the structure has been cleaned down, but before the materials and equipment for preservation have been ordered. The expert can carry out the inspection, draw up specifications for the preservation work, and estimate the quantities of material needed.

Amongst things that need to be done at this stage are the following:

6.1 PEERING AND POKING

Climbing all over the structure and visually examining it is the most obvious and important form of inspection. A screw-driver makes an excellent probe for poking into rot to see how soft it is and into fissures to see how deep they are. Colours and surface textures should be noted. Internal rot and rotted out cavities should be looked for. It may be far more extensive than you first thought [fig. 8].

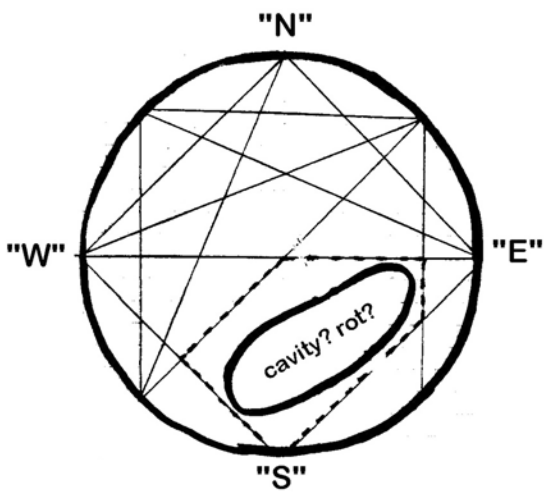
Pay particular attention to timber in the vicinity of nails, bolts, spikes and other fastenings, and whereever holes have been drilled. Fastenings driven vertically into horizontal timbers (e.g., where tramway sleepers have been spiked onto bridge stringers) are a likely cause of serious rot. Load-bearing

Fig. 5: Top chord and strut of a simple Howe truss, showing old inspection holes, some without hardwood plugs. Pukerua Bay road bridge over NIMT.

contact surfaces between horizontal timbers, e.g., where stringers sit on corbels, tend to develop pockets of rot with serious structural consequences.

If lighting is not good it might be advisable to bring a powerful flashlight or, better still, a possum-shooter's spotlight with backpack battery. A small shaving mirror or a motorcycle rear-vision mirror mounted on a stick like a dentist's mirror is useful for examining the undersides of bridge timbers without risk to life and limb.

Probing can be done more scientifically using a pilodyne. This is a spring- loaded device which drives a pin into the timber surface with a constant amount of force. The instrument is calibrated for each job by first of all measuring the penetration of the pin into sound wood on a freshly sawn surface. This distance is then subtracted from all subsequent measurements to give an indication of how deep dozy wood extends. Variation in depth of penetration accurately reflects variation in surface condition of the timber. In general this level of sophistication is not necessary, but it may be called for when an engineer needs to calculate the residual strength in a component with surface decay.



6a Initial scan detects cavity

Fig. 6: Use of ultrasonic decay detectors

In (a) the cavity (or rot) shown will block all rectilinear sound paths except those shown.

(b) Shows the sequence in which data is recorded. The sound source is held against the top of the log, at point N, and the detector is successively placed at E, SE, S, SW and W and the presence or absence of a detected signal is noted. The sound source is then moved to point NE, and the detector is placed at point SE, and so on. When the results are plotted, either manually or by computer, the presence of a cavity (rot) will be suspected in the dashed polygon.

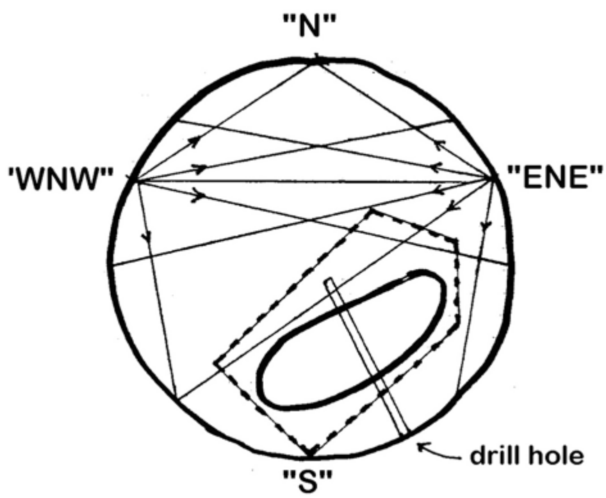
(c) If desired the shape of the cavity can be further defined, and the possibility of smaller voids in the other polygons eliminated by setting the sound source at, say, ESE and WSW and taking two further sounds of measurements.

Finally, a single hole drilled as shown will indicate whether it is a cavity, a shake, or a patch of rot which has been detected.

Signal detected ?

location of sound source	N	NE	E	SE	S	SW	W	NW
N			Y	-	-	Y	Y	
NE				Y	-	Y	Y	Y
E					Y	-	Y	Y
SE	-					-	-	-
S	-	-					Y	-
SW								Y

6b Sequence in which data is recorded



6c Cavity localised with dotted polygon

The old NZR and the MoW originally chiselled onto every piece of bridge timber the year in which that piece entered their yard stockpiles - an accurate indication of how long the timber has been exposed to the elements. In later years only replacement and additional timbers were dated. Timber from one bridge was often re-used to repair another bridge, in which case the timber has two dates - the year it was first used and the year it was re-used, separated by "SH" standing for "second hand". Often the depth in feet to which piles were driven below a chiselled benchmark is indicated by roman numerals.

These marks should be looked for and the dates noted. The results might be surprising. Some timbers might be older than the bridge, having served an earlier incarnation in some other now forgot-ten structure. Some timbers might be much younger than the rest of the bridge. Often the younger bits of timber are in worse condition than the old bits - thanks to the decline in timber quality over the years.

Fig. 7: Centre shake on kauri log in the Whitianga Museum. This would be indistinguishable from centre rot in an ultrasound scan. The shake is quite free from rot.

Besides close-up examination, it is also worth standing back and looking at the structure from a distance, and waiting to see what questions present themselves. Why is there more rot in the left half of the structure than the right? Why is one pile leaning more than all the others? What, if anything, is holding up that high beam I was walking on five minutes ago? (Gulp!) And so on.

Peering and poking at a structure prior to stabilisation is a bit like buying a used car. There are no hard and fast rules, it is all rather subjective, and the more structures you have looked at the better your judgments are likely to be. It can be done by a project manager new to this sort of thing, but it might be better to bring in someone more experienced. In the latter case the project manager should accompany the expert, to fully benefit from their experience.

Some suggestions on costing and scheduling a stabilisation operation are in section 13.

6.2 SOUNDING

A traditional method for discovering hidden internal rot and hollowness in standing timber was to strike the trunk with an eight-pound hammer. At a pinch the back of an axe will do. Sound logs give out a sharp ring, while hollow logs will give out a hollow-sounding thud (obviously). With a little experience internal rot and cavities in piles, beams, sleepers, etc. can all be detected by sounding - particularly useful for locating large internal defects or smaller ones close to the surface. Largely sounding is unsuccessful at locating small internal defects and determining the precise location of internal defects.

6.3 EXPLORATORY DRILLING

Generally destructive forms of investigation are to be avoided, but it may well be worth drilling a few exploratory holes into some of the more important structures, in particular to confirm the existence of cavities detected by sounding or scanning [section 8].

In softer timbers (e.g., kauri) this can be done with an increment borer that will remove a continuous core of wood which can be kept in a milkshake straw for future reference. Rot in the core can be detected by pressing with a fingernail. (Increment corers are expensive and easily damaged, but can sometimes be borrowed from botanists or silviculturists who use them for doing tree-ring counts without having to cut down any trees.)

In harder timber it will be necessary to use a twist drill or an auger. Spade bits can be used but they will go blunt very quickly in durable hardwood. The hole should be drilled a centimetre or two at a time, and the shavings removed and examined for rot. The shavings may be worth saving for closer examination later. If they are immediately sealed into a small plastic bag they can be used for determining moisture content. Variations in the speed of penetration will indicate variations in soundness. The depth at which the drill breaks through into any cavities should be noted. If a 14 mm bit is used the hole can be marked with a twig so that it can be used later for insertion of diffusible fungicide.

Holes drilled solely for exploratory purposes should be drilled horizontally or slightly upwards if possible. Afterwards, if they are not needed for diffusible insertion, they should be plugged by driving in at least 5 cm of preservative-treated over-diameter (15 mm) dowel. If the dowel is left protruding slightly the hole can be easily relocated for further inspection.

Bridge timbers will generally have very old 3/8 inch inspection holes in them. [See fig. 5] Some of these can be reamed out with a 15 mm bit to get further clues on what is happening inside large timbers. The very presence of these holes at particular locations in particular components indicates that some bridge inspector in bygone times must have suspected the possibility of internal rot there. A whole row of holes on a particular complement might indicate that the progress of internal rot was being monitored from year to year.

6.4 ULTRASOUND SCANNING

This is very simple in principle. An ultrasonic sound source is held against a timber, and a detector is held at various positions around the girth of the timber. Sound waves will not pass through rot or cavities, so the absence of a detected signal indicates rot or a cavity in the sound path. [Fig. 6] By repeating the process while shifting the sound source around the girth it is possible to map out the rot or cavity. Ultrasound scanning is carried out widely in New Zealand to detect internal decay in wooden power poles. The technique works in that it will definitely detect any rot or void in the sound path, but it also has a significant false alarm rate in that it tends to detect faults where none exist. Verification by drilling is not necessary but can help to define features of internal defects.

Both source and detector need to be in contact with sound wood. Alternatively, nails can be driven in deeply enough to encounter sound wood and the source and detector pressed against the nail heads.

The apparatus is expensive and it needs an experienced operator to record and interpret the results. Not all equipment and operators will be satisfactory, so credentials and the ability to produce the desired results will need to be checked carefully.

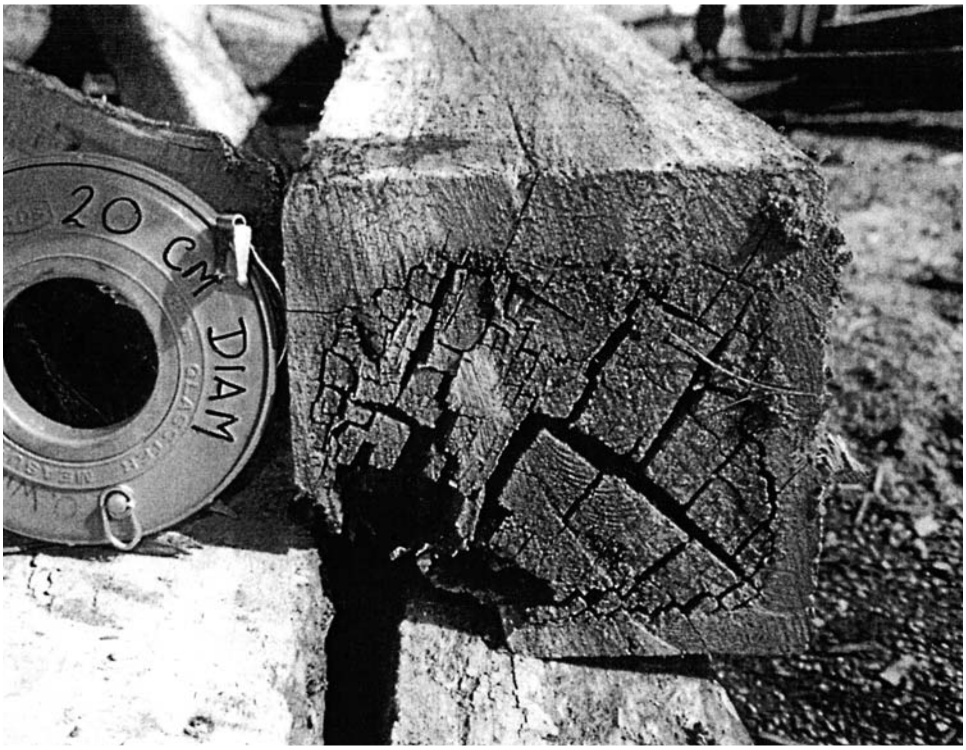


Fig. 8: A bad case of internal rot in kauri from suspension bridge tower in the Kauearanga valley. This rot was not evident until the post was cut down.

In general ultrasound scanning will not be justified for the sort of jobs we are involved with. There may, however, be some occasions when it can be useful, e.g., to earn a reprieve for a high-heritage-value structurally important component which a consulting engineer wishes to replace because of suspicion about its internal soundness. Ultrasound scanning is likely to be most useful and most effective for establishing the soundness or unsoundness of piles and poles.

A lay person's key to the identification of decay fungi: NZFS information series number 65, 1974. A practical guide to fungal damage of timber and wood products. J. A. Butcher.

6.5 GROUNDLINE INSPECTION

In any structure the worst rot is likely to occur where piles and other timbers enter the ground. Rot fungi thrive best in a zone that extends to about 40 cm below ground level. It is vital that at least a couple of piles be dug out to a depth of a half metre or so to see how bad the groundline rot is. It would be preferable if all piles were so inspected. If an engineer is scheduled to visit later the holes should be left open.

Usually it is not necessary to dig deeper than one metre, as very little fungal rot takes place in the near-anaerobic conditions at depth. On steep sites where soil creep and slumping is taking place there may be rot at greater depths. The groundline level may also change in streambeds and on, or at the foot of, slopes.

Sometimes there is amazingly little groundline rot, compared with rot elsewhere on the structure. This is probably because the old-time engineers were often cunning enough to use their very best timbers for piles, and their lower-quality timbers for superstructure.

6.6 IDENTIFICATION OF TIMBER AND OF ROT

If the structure is built of durable eucalypt then no further identification is necessary, since all the durable eucalypts react fairly similarly to fungal attack. Identification of durable eucalypts to species level on the basis of timber sample is quite difficult. However, from an engineering point of view, species identification is important in calculating strength.

If the structure is built from native timber now is a good time to positively identify the timbers. Original specifications for the structure may be available from archival sources, or small samples may need to be taken for identification by experts. Knowing what species of timber are present may be important in predicting how long the structure will stand and how safe it is, and may be significant in future preservative treatment or for determining the cause of any failure in preservative treatments. [See Appendix 3]

For identification purposes samples may be taken with a 20 mm chisel. A sliver of sound wood 3 mm thick and 40 mm square will be more than sufficient. Identifications can be done (for a fee) by experts.

For the record it may be useful to know what kinds of rot are present. Brown rot and white rot are reasonably easy to distinguish. Soft rot is a bit more problematical. A layperson's key to identifying fungal infections in wood has been published by the Forest Research Institute Limited. Laboratory identification of fungi to species level is expensive and unnecessary. Deterioration due to weathering (sun and rain) should be distinguishable from deterioration caused by fungal rot. The presence of tunnels made by wood-eating insects should be noted. Size and shape of exit holes can be noted for later identification.

6.7 PHOTOGRAPHY AND DOCUMENTATION

Take lots of photos at all stages of a stabilisation project, but particularly before and after cleaning down. The photos can be used to document the extent and severity of deterioration. The remains of components which are to be replaced should be photographed before removal. Any components undergoing structural failure should be photographed. It is worth photographing locations at which investigative holes have been drilled or wood samples taken. Photos can supplement samples for later identification of timber species and type of rot.

Photos are usually best when taken in overcast weather. Use of high speed film is preferable to use of a flash. There should be either a scale, or a person or familiar object present in the field of view to provide scale.

It might be worth establishing permanent photo-points where photos can be taken at annual or greater intervals as part of the long term monitoring of the structure's overall condition. All photographs should be captioned and dated before being filed away. In section 5.1 it was suggested that sub-structures of larger structures need to be numbered. Any such numbering system should be used in the captioning of photos.

Written notes should also be made. These will cover topics such as peculiar methods of construction employed, the distribution of various types or species of timber in the structure, the nature and seriousness of structural faults, and the degree and extent of rot. Photography and note taking may be supplemented by simultaneous imagery and spoken commentary recorded on a home video camera.

6.8 PLANNING REST OF OPERATION

Once inspection, photography and documentation are completed detailed planning for the remainder of the project can begin, contractor specifications written, and costs estimated. There are two main issues that need to be thought about.

The first is the extent to which timbers need to be repaired or replaced rather than treated. Decision-making will be based largely on engineering considerations of strength and stability.

The other issue is that of timing. It is crucially important when applying surface treatments that the moisture content of the wood be as low as is reasonably possible. This generally means doing the job in late summer or early autumn. Wood moisture levels tend to lag behind seasonal weather changes, so that even if autumn rains have begun timber moisture levels may well be lower than they were early in a dry summer. Rain, sun, wind and humidity are all important in controlling moisture level, and it may be helpful to consult with your Conservancy fire Technical Services Officer (TSO), who is monitoring these sorts of things all the time. Low timber moisture content roughly equates with high fire risk.

Controlling internal rot is usually less urgent than controlling surface rot. (A 10% loss of diameter on the outside will weaken a component more than a 60% loss of diameter on the inside. See Appendix 2.) But now is the time to decide whether internal rot and groundline rot should be treated at the same time as surface rot, or left until later.