KNOWLEDGE GAPS IN THE SUSTAINABLE PROVISION OF LOW VOLUME RURAL ROADS

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Introduction

Before looking at knowledge gaps let us consider the whole process of acquiring knowledge and using it successfully. To begin with we will assume the knowledge we require is already 'out there somewhere'. In other words, solutions to our problem are known elsewhere in the world. The question is, 'How do we obtain this knowledge?'

If we are lucky enough to live in a place where internet access is available we can search the worldwide web. The web will almost certainly contain the knowledge we require but there will be two problems. The first is that there will be so much 'knowledge' available that it will be difficult to filter it and decide what we really need. Secondly, most of the information will be in English or in the language of another developed country, and not in our native tongue.

This immediately indicates that a knowledge management system is needed that operates at a national level to provide access to this knowledge for all the engineers that need it. The knowledge needs to be filtered and made available. Some of the work of filtering this knowledge may have already been done by an International Organisation such as DfID, IBRD, TRL, GTKP, but the final dissemination locally can only be done by a national body. An essential outcome is that any new methods must eventually be incorporated into national specifications and standards and these specifications and standards must be kept up to date on a regular basis.

If we have no internet access, then, although this national knowledge has been provided on a web site, we will have to rely on printed versions and therefore these must be readily available to all engineers.

The next step is to ensure that the knowledge is used properly and this means that adequate control of quality is vital. Poor quality wastes resources and reduces the amount of road access that can be provided for local people. Contractors and their supervisors must follow the specifications and quality systems must be in place to promote this.

Finally all infrastructure must be maintained. Roads, in particular, can deteriorate very quickly if maintenance is inadequate, hence ensuring maintenance is vital.

Thus although the technical knowledge is an essential starting point, knowledge of how to provide all the other steps in the chain to ensure that the LVRRs are built to the most appropriate designs, to acceptable standards and are maintained to ensure long life are equally important. This knowledge may not be considered as part of fundamental knowledge gaps because these problems have been solved in many countries, but the local situation will never be the same as elsewhere. The barriers to providing sustainable LVRRs will always be unique because, although some of the individual barriers may be common, every situation will comprise a specific set of such problems that have not been solved before.

Knowledge

If we look at the history of new knowledge there is one vital lesson to appreciate and that is that new knowledge usually takes a long time to be accepted. To give two example;

The Copernican Revolution

In about 1510, Copernicus discovered that the earth is not the centre of the universe but moves round the sun with the other planets. He did not publish this until 1543 (His book was entitled '*De Revolutionibus Orbium Coelestium*') but it took another 200 years before it was fully accepted.

Plate tectonics

This is the theory of the large scale movements of the earths crust. It was first postulated in 1912 by Alfred Wegener and then expanded by Arthur Holmes in 1920 and 1928 but it did not become mainstream until the mid 1960s, 50 years after it was first discovered.

The typical period for the acceptance of new knowledge is one professional generation (the Copernican revolution was an extreme case) and this is just as true for advances in engineering knowledge as it is for major scientific advances.

For example, between 1976 and 1979 TRL International first showed that, in hot countries, asphalt pavements rarely fail through bending fatigue. All cracks in asphalt surfaces started at the top and went downwards, quite contrary to the usual 'theory' of pavement failure.

It took 20 years for this to be accepted by the profession and is now acknowledged as the principal form of failure of thick asphalt layers even in temperate countries. It has obviously had an enormous impact on maintenance costs and repair strategies, but it was a surprise that it took so long for the profession to accept it.

Technical Knowledge Gaps in LVRR Engineering

For heavily trafficked roads there are several serious technical gaps but for LVRRs the situation is a little different. In general the behaviour of LVRRs is well understood but some of that knowledge appears to have been forgotten. Many examples of bad practices are evident worldwide. Furthermore, as with any technology making use of local and, usually, unprocessed materials, there are important gaps in knowing the best way to do something in specific circumstances.

For LVRRs one key aspect is choosing a suitable structure and surfacing. Although we do not know quite how well or how badly a road will perform in any particular circumstances, we can probably guess which options are most likely to be the best. The problem is choosing between them, assuming we have a choice. There are essentially two problems that affect the ultimate behaviour of the road namely the natural variability in performance that occurs despite good quality control and the additional effect of poor quality control itself.

Natural variability in performance is one of the main reasons why we do not know the answers to many of our outstanding pavement questions. Research studies that are not comprehensive enough to establish statistical reliability often produce seemingly conflicting results. We need to identify the *average* performance of each type of structure in order to choose the best options, and this must be based on realistic levels of local capacity. When variability is high, this is particularly difficult.

For example, consider structure A and structure B. If constructed to good standards we can expect structure A to last an average of 10 years before it requires major maintenance but structure B will only last 8 years. If we are lucky, structure A could last for 15 years and if we are unlucky, only 7, such is the natural variability that occurs. It could be argued that if we understood behaviour better, then we would be able to predict performance more accurately. There is some truth in this, but during the life of a road the effects of climate and environment cannot be known accurately in advance hence prediction is difficult.

Depending on cost components and possibly a Whole Life Cost calculation, we would choose structure A. However, if we consider what will happen if quality control is poor, we obtain a different picture. Structure A is technically more difficult to construct properly than structure B hence poor quality control is likely to have a more serious effect on it. In this example, if quality control is poor, the average life of structure A is reduced to only 5 years whereas the effect on structure B is much less and the expected life decreases only to 7 years. Now structure B is more attractive.

Although this is a hypothetical example, knowing the average life expectancy of different options in different local situations is necessary if we are to choose the best options for each situation. Because of variability, this knowledge is denied us at the moment.

For a single road, this may not very important but for a network of say, 10,000km, it becomes very important. Overall costs can be reduced by anything up to 60/70% by making the best choices and therefore many more roads can be provided for the same total cost.

It is a statistical problem that can only be solved with lots of data. Regular, but not necessarily expensive, monitoring of the network would, after a few years, show which designs were working best. In other words a simple Pavement Management System is needed. Unfortunately it has proved difficult to install and operate a PMS successfully in most countries for a variety of reasons, some of which include some of the barriers to implementation that are discussed later.

Personal Knowledge Gaps

A knowledge gap can be personal, national or international. If I want to build a road, but I don't know how, then I have a personal knowledge gap. But if I know how to find out (through National or International knowledge management systems) my knowledge gap *appears* to be only temporary. Is this really true? I may not know whether the knowledge is applicable in my particular circumstances and so I will lack confidence, hence in this sense I still have a knowledge gap.

In engineering we use materials that are extremely complex (though, fortunately, relatively inert). However we can never be sure how they will behave in all situations. Thus engineers are very conservative by nature. This is because the history of engineering is full of examples where disasters have occurred when,

(a) the engineer has pushed the boundaries of knowledge too far, or

(b) made a mistake by deviating from the accepted method.

Thus most engineers lack the confidence to try new but proven methods even if those methods are known to work elsewhere. Therefore it is understandable that this kind of personal knowledge gap is very common.

Methods that are new or merely unfamiliar to the engineers concerned are normally introduced by means of demonstrations. Unfortunately this process is usually slow because engineers are aware of variability and aware of salesmen trying to promote a commercial option, hence a single demonstration is never enough. Demonstrations usually have to be repeated many times before the new method is accepted. It also helps enormously if the demonstrations are lead by an authority that is completely independent of commercial interests.

Mainstreaming Problems

If the only problem was the conservative nature of engineers, mainstreaming new techniques would be much easier than it is. This is because there are barriers to 'mainstreaming' other than merely the behaviour of careful engineers. These barriers can be classified in many ways. Some are institutional, some social, and some cultural, although some can only be described as laziness or lack of professionalism. But, however they are classified, they are often very difficult to identify and are always difficult to remove. An example from UK will illustrate this.

Recycling Asphalt Paving Material in the UK

In the UK a great deal of research was done by TRL to show how old asphalt pavement layers (which contain sound aggregates) could be re-used/recycled in road building. Manuals were written and specifications developed based on long-term performance studies that illustrated the quality and durability that could be achieved. The benefits were enormous and included,

(a) Cheaper aggregate because fresh aggregate usually has to be hauled a long distance

(b) Less pollution from quarrying operations and the transport of fresh aggregate

(c) Less material going to waste

(d) More sustainable because sources of good aggregates are being used up

(e) And more

The problem was that the technique was not being used; it was not in the mainstream. The question was, why ?

TRL carried out a study in 2001 to try to get to the root of this problem. This resulted in a 170-page report entitled *'RECYCLING IN TRANSPORT INFRASTRUCTURE'* written by J M Reid and J W E Chandler.

The reasons were discovered through a great deal of painstaking work by many people committed to finding the answers. In short, the reasons were as follows,

(a) Unfamiliar specifications

(b) Different test methods

(c) Concerns over reliability and quality control

(d) Environmental concerns

(e) Regulations for Waste Management (legal issues)

(f) Building regulations (legal issues)

(g) Conditions of contract

(h) Supply and demand

(i) Economics

(j) Lack of Awareness (despite widespread publicity)

Without going into all the details, some of these appear to be weak excuses but the most serious reasons stemmed from regulations drawn up to protect the environment from pollution by waste products. Unfortunately old asphalt pavements came into this category despite the fact that the regulations were drawn up primarily for potentially dangerous industrial wastes. The materials in old pavements are no different to those in new pavements and therefore the regulations covering those materials should have applied. Unfortunately the decisions of environmental officers across the country were not consistent and so contractors gave up the attempt at using the new techniques.

But laziness also played its part. In one county of the UK, the reason given for not using the recycling option was simply that '*we meet our targets for recycling by recycling domestic waste from households so we do not need to do any more!*

In total this list provides an almost impossible set of barriers. Lack of confidence by the engineer is probably the easiest to overcome. Some of the others are much more difficult, especially those affected by legal requirements even though those requirements were really not appropriate.

Despite the depressing nature of these conclusions the report included recommendations on how to overcome these barriers and it is encouraging to report that some success is being achieved.

The lesson for us is that the mainstreaming problems can be complex and unexpected. Thus they are worthy of detailed study in each situation because it is important that we overcome them.

Other Issues

Economic Justification for Project Selection.

Identifying the best way to spend limited funds remains a problem. First of all the economic evaluation of transport by bicycles, motor bicycles, motor cycle taxis and forms of transport other than cars and trucks seems to be inadequate. Secondly, although valuing social benefits in economic appraisals has advanced a great deal in recent years, I believe there is more that can be done.

Presentation of Knowledge

The way that knowledge is presented can be improved considerably. For example, the specifications in use in some countries are too prescriptive. They tell the contractor how to do almost everything ranging from the trivial to the critical. The result is a thick document that is never read properly, if at all. Specifications should focus on the key aspects and, if thought necessary, be supported by other documents that are merely instructive.

These instructive documents also need to 'user-friendly'. Thus in my view they should be relatively short and succinct documents that focus on particular topics. For example '*How to design and construct a surface dressing'* or '*How to make a mechanically stable road base'.*

Summary

The path from the creation of new knowledge through to its use in practice involves barriers both known and unknown.

The principal knowledge gaps are in understanding these barriers and in knowing how to overcome them.