Responsibility for Quality in Highway Construction*

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Highway contracts invariably specify that the contractor is responsible for the quality of the work and that any default will result in dire penalties. However, for reasons of convenience, protection of their interests and because qualified staff and the necessary facilities were available, highway departments have tended to assume responsibility for routine testing and the inspection necessary during construction to achieve the specified quality, as well as that required for acceptance purposes alone. There are obvious inherent incompatibilities in this dual approach which the more complex, demanding, rapid and automated processes of present construction may aggravate to the point that, in practice, nobody actually feels responsible for quality control and the incentive to do a good job is lost. In addition, serious doubts have arisen in recent times as to the adequacy of present methods of sampling and the significance of many tests conventionally used for the control of highway construction materials and processes or acceptance of the resulting product.

Legal, philosophical, statistical and other experts, in pressing their attack on the present system, have offered solutions, based on statistical concepts, for the drafting of specifications and for sampling and testing. They have also advocated complete assumption of responsibility for control by the contractor to insure quality as work proceeds before submitting it for acceptance by the highway engineer. This presents a challenge that the highway engineer must face and resolve through discussion and research to either:

1. Justify the validity, economy and suitability of present practice; or
2. Introduce modifications to present practice, to up-date it in light of changing conditions; or
3. Evaluate the alternative approach and accept it if it appears superior and is compatible with highway construction procedures.

In any case, (and this may well influence the choice) a realistic reevaluation of inspection procedures and sampling and testing methods is urgently needed.

Thoughts on this whole problem are not too clear at the moment. If you ask a group of highway engineers what they mean by quality control you will probably get as many different shades of opinions as there are people present. Thus, before we can decide who should be responsible, we have to answer another question first: "Responsible for what?"

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The subject is, in fact, so controversial that I think we might get a lot further and tread on fewer toes on the way if we resort to a stratagem as old as the biblical parable and tell the tale of the speeding motorist.

On our highways, state or provincial legislators expressing the wishes and welfare of the community as a whole, have passed laws to limit the speed of vehicles. The limits applicable to a particular stretch of highway are then set in relation to the type of road, its environment and the traffic using it. The limit is then clearly posted so that the user knows the speed he should not exceed. He is also warned, by signs, of specific hazards that may require restrictions on speed in the interest of safety (including his own) at certain times, for example, school zone or pavement slippery when wet. This, of course, is the equivalent in construction processes to the contract specifications and the supplemental specifications or special provisions.

The next stage in the control of speeding is for the established limits to be enforced by the police in various ways (equivalent to construction inspection and testing). A judge or magistrate (the engineer) then determines, from the evidence presented, if an infraction of the law (or contract) has been committed and what the penalty should be.

A driver stopped for speeding may be surprised since the speedometer in his car indicated that, as far as he was concerned, he was driving just within the limit. On the other hand, the speedometer in the following police car must have shown otherwise or presumably he would not have been stopped. This is an important point because it illustrates that essentially the same type of test equipment does not always give the same results in the hands of different people. Further inquiry on this point might show that the reason for this lies in the different construction of the speedometers, even to the extent that one had been purposefully designed to read wrong, as has been reported on some cars in order to indicate better gas mileage than in fact is the case. Another reason might be operator error because the angle at which the needle was read in relation to the numerals gave a false reading. A more obscure reason might be that since the reading depends on the circumference of a tire, such an unlikely thing as differences in tire pressure was the cause.

Similar factors affect tests on materials and are the reason why precision statements are now considered an essential part of any test method. While precision is important, it is not everything. Consideration must also be given to alternative, even less accurate, tests to measure the same thing, to determine if they are preferable in a given set of circumstances because they are more convenient, rapid or effective.

Because it is difficult to catch alert speeders by following them, the police have resorted to other methods of measuring speed, such as radar or spotting from aircraft. Radar is technically more complicated but it is probably more accurate, even though it is still subject to error from external influences. Where concealed, it probably catches more offenders and is thus apparently more effective. This is not necessarily so if by effective we really mean making sure the law is complied with. There is nothing to beat the psychological effect of a clearly marked police car patrolling a highway; motorists proceeding in both directions slow down for several miles even when nobody is actually stopped and charged. Aircraft speed surveillance is also equally effective though, in this case, the method of measurement is different involving only the simplest of means—a stop watch clocking cars over a marked distance on the pavement.

Considering these points in relation to construction control, it is clear that the advantages of alternative tests to measure the same thing must always be considered. Selection for use must not be on the basis of accuracy alone; the ease of testing and psychological factors must also be taken into the assessment of effectiveness. Wherever possible, testing and inspection should be in

the open; no attempt should be made to catch the contractor out by a trick that will undermine mutual confidence and destroy the feeling of responsibility.

Experience has taught policemen that, while the law says an offense is being committed at 1 mph over the limit, he is unlikely to secure a conviction unless the offender's speed can be clearly shown to have been substantially above the limit. In deciding what is substantial, the policeman may be more tolerant of speeding on a rural highway where there is less danger than he would be in an urban school-zone where the consequences could be serious. The judge or magistrate also considers not only the factual evidence in reaching a decision, but also the circumstances of the occurrence. A plea from a doctor, for example, that he had exceeded the speed limit to reach an emergency case, might well be taken in mitigation of the offense or its penalty. In pronouncing sentence, the judge should have considered if it was a first offense or if the offender had shown repeated disregard for the law.

Tolerances (including the influence of the precision of the test method used and the limits set) and judgment are similarly important factors in enforcing construction or material specifications. Logically, it would be desirable to reduce the influence of opinion to a minimum so that, in the same circumstances, every engineer would arrive at exactly the same decision. The ground rules, especially for tolerances on specification limits in relation to the precision of the test method, should be clearly spelled out so that the personal element is reduced to a minimum. There must, however, be freedom for the engineer to assess the significance of the deviation from specification in relation to the work. Whether removal and replacement or simply some financial or other penalty is appropriate calls for engineering judgment of a high order in each specific case.

Having been caught, the motorist may decide on one of two courses of action in the future. He might decide to continue driving in the same old way and take the risk of being caught again. This, unfortunately, is what most contractors seem to do; where their "speed limit" for the work is 60 they still try to set the needle on 60 and hold it there, or even exceed 60 if no enforcing inspector is in sight or they sense that one is unlikely to be about. Alternatively, he might decide that 60 is, after all, the limit, and to be sure it is not exceeded he'd better set his average speed at 55. This attitude is obviously to be preferred by the community, as a whole, since it is only the motorist who, by his own actions, can control his compliance with the law all of the time.

The same preference must surely apply to construction control. If so, the contractor must be held responsible for control operations, including testing, necessary to insure compliance of his product with the specification at all times. This is not to say that the highway engineer should turn his back and ignore what is going on. Since it is obviously impossible for the police to monitor the speed of every car that is on the road all of the time, recourse is made to spot checks. Speed traps are set up either at random times and locations or where infractions are most likely to occur and are potentially most dangerous. This principle of enforcement by making only sufficient check tests or spot inspection to insure overall compliance with the specified limits is, on the face of it, equally applicable for construction and materials acceptance purposes.

Another useful device, which is the equivalent of the motorist receiving demerit points in addition to a fine, is that of prequalification of contractors with reductions in qualification for infractions of contract. If the prequalification system puts great weight on the seriousness of technical and quality infractions, then it can be of considerable value in reinforcing all the other measures described and can lead to the contractor being made to accept a sense of responsibility for quality.

The essence of the parallel drawn is that speed limits are generally obeyed and the law upheld by a combination of the chance of detection by a less than 100

percent accurate test based on random sampling, and the threat of punishment forcing the driver himself to control his speed. Since almost the same considerations appear to govern the control of highway construction, a similar approach to the problem might best attain the desired end. The complexity of the materials and processes used for building highways certainly makes the problem more difficult but this does not invalidate the principles involved.

One alternative to this approach would be for the law enforcement arm to put its own driver in every car and let the "normal operator" ride as a passenger. This, in fact, is what our highway department does and I suspect many others currently do the same. They carry the contractor as a passenger and then wonder why he feels no sense of responsibility when something goes wrong with the car! Maybe the reason we do this is because we feel from experience that contractor drivers are not technically competent to drive modern cars. This is often so because we have not let them try driving anything other than a horse and buggy. It is possible that, if we don't want to go the whole way, we should at least compromise and put the contractor in the driver's seat but insist that the car be fitted with an automatic speed control device. This is what is happening widely in the construction industry today through the automation of equipment and processes, for example, at batch plants or on pavers with automatic screed controls. We do not, however, appear to have realized the full implication of the impact of automation on the control function.

The chance of human error has been drastically reduced and automated processes are, in any case, now largely beyond manual inspection and control by the highway department's staff. The traditional batch plant inspector looking over the shoulder of the weigh scale operator is now a useless thing of the past. Neither of them, in fact, can understand or even see what is going on, let alone influence it! Few would disagree that the contractor must be held responsible for the correct operation of such automated processes. This implies to all intents that he controls the operation which means, in turn, that he controls the quality and the highway department can only inspect and test the product for acceptance purposes. If tests are needed as part of the control function then the obvious person to make them and apply the results is the contractor. Doing it this way, rather than relying on secondhand results from highway departments, has the added value of making the contractor both interested and aware of the significance of variations in quality and the benefits and profits of uniformity.

Both the contractor and highway engineer are in need of new simple accelerated tests for many material properties if they are to be in a position to influence quality for the better. These tests, when used for both control and acceptance purposes, will also require the use of rapid data handling, processing and analysis of results if control is to keep up with the pace and complexities of new and automated methods of construction.

The introduction of new construction processes is often hampered by the inflexibility of the specification for the work, which describes in detail each conventional step for the execution of the work. This leads to a feeling on the contractor's part that highway engineers are only interested in playing it safe, not in progress. Responsibility for quality at the time of construction is only a step on the way to responsibility for the satisfactory nature of the end product to perform its intended function. Therefore, there is obvious merit in end result performance specifications. If these can be made to work they would satisfy the highway engineer's responsibility for providing a durable, value-for-money road, while allowing the contractor to exercise initiative in the way he builds it; thus reducing costs.

In the past, practice has not often proved the theoretical advantage of this approach. It has been considered both costly and unsatisfactory since contractors, through posting bonds or anticipating that a percentage of the work will

require replacement over the years, tend to inflate their bid prices, or there is extreme difficulty in getting them to accept responsibility for the remedial work at a later date. Furthermore, since the contractor did not design the structure, the fact that faulty design or specification played no part in the failure must be first established.

Looking again for inspiration to the motorist for whom the highway is being built, it is now apparent that performance specifications can and do work given the right circumstances. The automobile industry now commonly offers 50,000 mile power train warranties and the like. They can do this, at apparently no increase in cost because they have brought their own quality control testing and inspection systems up to a high level of efficiency. Is it, therefore, unreasonable to contemplate asking a contractor for a 1,000,000 load application warranty for a pavement?

It has been mentioned that performance depends on the design of the pavement structure at least as much as on the quality of materials and construction used. In the long term view it may be worth considering reverting to the system used in days gone by to build the railroads and other major civil engineering works. The State or Province of Utopia would only specify that a road on a certain alignment with given geometrics and volume and load capacity was required from point A to B. The contractor (or alternatively the government itself) would then be required to design, build and guarantee the performance of the highway. This would be the ultimate concept in responsibility.

In summary, either we continue to chauffeur the contractors in government-owned automobiles and accept responsibility for what happens, or we must make them drive their own cars and let them both feel and be responsible for the quality of their product. If necessary, we could insist on speed control governors or 50,000-mile power train warranties to provide additional safeguards. Furthermore, there is an alternative and ultimate concept of "design and build" responsibility that should be considered. Which it is to be is up to you and the taxpayer to decide. Let us retain an open and clear mind as to the nature of the problem and get down to evaluating properly the alternatives and developing the new tests or procedures necessary to make "responsible control" work.