

# FUTURE DEVELOPMENT OF THE ART AND SCIENCE OF HIGHWAY ENGINEERING

Thos. H. MacDonald  
Commissioner of Public Roads

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The Technical Program Committee for the American Society of Civil Engineers Centennial Celebration, - Messrs. Wallace L. Chadwick, Francis S. Friel, Craig P. Hazelet and Chairman G. Donald Kennedy, assigned a subject that entices the imagination to wander in distant fields. The truly fantastic magnitude of this engineering product we presently term highway transport, and the depths and ramifications of its penetration into the social and economic patterns of our national life, defy full understanding. The projection of its future outreaches the accepted methods of prophecy. Fortune-telling and crystal-ball gazing are not practiced by the engineering profession. It may be that, in his complete disdain of these ancient arts, the engineer hitherto has forfeited in some measure means to the leadership of public thought and public policies that he is by training and experience fitted to command. Certainly it will be accepted generally that far-seeing leadership is needed now in the whole field of highway engineering in a degree far surpassing the requirements of the past.

But, in place of the illusions of the crystal ball, the experienced engineer now has proven techniques and yardsticks approaching divination power, to ascertain the factual components of a soundly charted course into the future.

The American Society of Civil Engineers, celebrating its one-hundredth birthday, has the proof of engineering advances across broad fronts vividly presented by the exhibits of the Museum of Science. Pride in the proven record of accomplishment is a natural human reaction. Complacency in that pride at this period can well be the real cause of a disastrous loss of leadership. Having created his potent tools of change, the engineer cannot now fail to recognize the consequences of their use or disclaim responsibility for confining their power to constructive purposes.

In a recent issue of a Chicago paper, in a story about the convocation of engineers, appears the following sentence: --- "However, the old-line engineers aided by the slide rule, and the blueprint boys working in anonymity, have long since proved their ability." One of the facts submitted to prove the statement is that millions of Americans can now ride coast-to-coast in three types of transport widely different in character. As a statement of fact, no-one will deny its authenticity, but no engineer who knows transportation will agree that the several types of transport available have yet been integrated into systems of ultimate economic potential, or even optimum present service. The principle here involved is of great moment, not only for highway engineers but for engineers in many other fields, since identical implications cut across many areas of our economy. The engineer, having created potent tools for change, has taken on the responsibilities of a work that will never be done. Why this is true becomes apparent upon analysis of the subject of this discussion.

Definition of terms:

Common usage does not distinguish the sense of the terms "art" and "science" along exact lines. The standard dictionaries permit a degree of interchange between them. If traced back to their Latin origins there appears to be substantial support for more precise limitations on the use of the terms in a technical discussion, as, for example:

Art (L - ars) - skill in performance acquired by experience, study or observation, and a systematic application of knowledge or skill in effecting a desired result.

There is ample authority to limit here the use of the term to the application or practical use of acquired skills and knowledge.

Science (L - scientia) - an order of systematized knowledge or a branch of study concerned with the observations and classification of facts, especially with the establishment of verifiable general laws, chiefly by induction and hypotheses.

Science, thus defined, can and does exist as an entity without any application to the solution of problems.

Objection may be made that these definitions are too narrowly limited, since there are marginal overlapping areas which have the characteristics of both art and science, but this objection does not invalidate the conclusion of the discussion; so, first, consider the current status and future promise of highway engineering science.

### Science and Highway Engineering

A listing of the most important current researches, tests and

observations, extends into these general fields:

Soils - including soil mechanics, soil chemistry, soil maps.

Construction materials - including asphalts, tars, stone and gravel aggregate, cement, concrete and bituminous mixes.

Structural design of roadways - including subgrades, sub-bases and wearing tops.

Bridge materials and design - including prestressed concrete, welded joints, continuous spans, deep foundations.

This is still an incomplete list of the physical and chemical researches only now under way by many agencies and in many laboratories. Equally important are the economic and financial studies of many phases such as: traffic flows, both qualitative and quantitative; driver behavior; traffic capacities, including the influence of design; highway finance, including benefits; highway needs surveys; traffic forecasting in relation to anticipated economic development; highway net patterns, including highway classification into logical systems; regulation of traffic, both loads and speeds.

The laboratory facilities now available are extensive and modern --- not universally as yet, but there is constant building. The research worker has been quick to make use of the most recent wonder tools of ultra-microscopy, electronics, ultra-sonics.

Through the association of research personnel in such organizations as the Highway Research Board of the National Research Council, a spirit of free giving and taking of new knowledge as it develops is perhaps the fullest guarantee possible of the certainty of future progress of the science of highway engineering.

Every element necessary to insure the advance of our verifiable knowledge in the broad phases of highway engineering is in operation. The scale of operations is becoming adequate, as the Maryland and the Idaho cooperative tests bear witness. The interest in research of officials, industrialists and users, is constantly focusing more closely on the same objectives.

There is the inescapable conclusion that progress in the science of highway engineering, i.e., verifiable knowledge, will go steadily forward and be constantly adequate to our needs when fully applied.

#### The Art of Highway Engineering

Future performance in this field is uncertain. Currently, performance is inadequate and has been in the past. It is in this field that the highway engineer must exert a more determined leadership.

Progress in the realization of an adequate and efficient highway transport for all parts of the nation will be governed by the degree to which the highway engineer and highway administrators are permitted to carry into effect the science of highway engineering included in the complete concept of highway administration. There are certain "musts" for the highway engineer or administrator himself.

The highway engineer must recognize that the field of highway engineering is not confined to the construction and maintenance of the physical structure of the highway. He must recognize more fully that his responsibility is related broadly to the development of highway transportation generally, - that the purpose of highway engineering

is to move people and goods quickly and safely.

The highway engineer must recognize that highway transportation is an integral part of the economy of the nation. Development of a highway transport system adequate to permit national economic and social growth requires also the determination of the proper relation between highway transportation and other forms of transportation.

There must be recognition of the need to fit highway transportation in urban areas into the changing character of those areas. It must be accepted that "decentralization" of urban areas, whether good or bad in theory, is in fact in process. The automobile is re-making the American city, and no problem in the immediate future seems to offer greater challenge than the problem of guiding the re-development of metropolitan areas to fit the desires of the people inspired by the new flexibility of highway transport. Proper planning of highway and integrated terminal facilities can do much toward stabilizing old, and creating new, values.

The problem of safety requires a direct and independent attack rather than treatment as a collateral adjunct or by-product of other activity. Important steps are:

- (a) Broader application in highway design of principles already proved.
- (b) Improvement in design and regulation of vehicles. Much opportunity exists for changes in physical design to reduce not only the number of accidents, but also the seriousness of their consequences.
- (c) Action toward greater uniformity of regulations and

improvement in traffic control devices, particularly in highway signs.

How to evaluate the future of the art of highway engineering, that is, the actual application of science to secure desired results, involves these perplexing questions. How much highway improvement shall be undertaken and at what rate? Decision upon these questions does not lie directly within the authority of the highway engineer or official. It is within their discretion to become the advocates of two essential concepts. The first of these is that our highways must have a completely integrated pattern for improvement and continuous maintenance, no matter how many systems or classes may be involved, and their future administration by the several units of government must be cooperative and not competitive. The second is that this important objective will require a complete overhauling and revision of highway laws in most of the States.

Down through the years of history the highways have reflected the efficiency, even the integrity, of government. A common but mistaken belief is that great road systems of the past were built as military highways. The fact is overlooked that these systems were built, after conquest of territory, for administration and economic development, and not primarily for military purposes.

The conclusions that emerge from this brief review of a subject of such magnitude and such diverse ramifications are: first, that we may with confidence expect the science of highway engineering to grow and to provide new and refined knowledge reasonably adequate to our needs; second, that practice of the art of highway engineering will be seriously

handicapped for an indefinite period, should we fail to revise and to modernize the laws which govern highway development.

If there is any disposition to question this latter conclusion, consider one essential element of our highway administrations, - the technical personnel. No matter how sufficient the science, i.e., the knowledge of how to design, construct and maintain roads, the application of the knowledge will be inept without competent technical organizations. How many of the State, city or county governments have now or are in the process of making effective laws to adjust salaries, provide reasonable retirement annuities, attract engineering graduates to enter a career service, or extend in-service training to promising employees?

The future development of the art of highway engineering will be a test, not of highway engineering science, but of government itself. The possibilities of securing for the common good the constructive and desirable services of highway transport made possible through science, and of eliminating the destructive elements, will be determined by the progress in better laws and effective organization of government. The highway engineer needs to assert leadership in securing, through a thorough modernizing of highway laws and governmental organization for highway administration, the opportunity for highway engineering science to mature usefully into the art of highway engineering.